NEURORADIOLGY

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4 ventricles: 2 lateral ventricles, connected to the 3rd by the foramen of monro.. 3rd & 4th connected by cerebral aqueduct of sylvius

White matter connecting 2 hemispheres: corpus callosum (rostrum, genu, body, splenium)

CT: you take axial, then reconstruction on the computer to get coronal section
MRI: multiplanar: axial, sagittal, coronal.. (T1, T2 or FLAIR)

Conventional angiography is invasive (like heart catheterisation), it's the gold-standard but is invasive..
So, Angiography using CT or MRI are good substitutes + are non-invasive

Ultrasound: hypo- or hyper- echoic (hyper is bright, hypo is dark)
X-ray: radio-opaque or radio-luscent
CT: hypo- or hyper- dense (bone is hyper-dense , white.. While fluid is hypo-dense)
MRI: signal intensity…

T1>> fluid is hypo-intense (black), WM is white, GM is grey
T2>> fluid is hyper-dense (white), WM is grey, GM is white
FLAIR>> same as T2 but fluid is black (Fluid-attenuated inversion recovery)

Neuroradiology

- Neuroradiology is a subspeciality of radiology focusing on the diagnosis and characterization of abnormalities of the nervous system, spine, head and neck.
- The imaging modalities include:

- **Plain radiography**
- **CT scan**
- **MRI**
- **Angiography**: is being replaced in many instances by MRA
- **Ultrasound:** is used in limited circumstances.

Neuroradiolgy / investigation

Plain film

The plain skull film may reveal:

- Calcification
- Pituitary fossa enlargement
- Bone lesion or secondary deposit.
- Fractures

■ In macroadenoma >1cm .. may cause bone erosions
■ Bone lesions : as in pts of multiple myeloma→ on lateral skull x-ray we may see bone lesions

Very limited role in imaging the brain
We can use X-ray to rule out fracture but we typically use CT scan since it gives a clearer picture about the injury

ULTRASOUND

- The neonatal brain can be scanned through the open anterior fontanelle for:
  - Hydrocephalous
  - Interventricular or intracerebral hemorrhage
  - Suspected intracranial pathology.
- Doppler studies are used for the diagnosis of carotid artery stenosis.

Neonates have the ant & post fontanelles + the mastoid process is cartilaginous – not ossified

★ craniosynostosis : when the sutures or the fontanelle are prematurely closed in infants before the full formation of the brain

★ Treatment by opening the sutures, to allow the baby's brains an adequate space to grow and develop.

★ Doppler for carotid artery : in elderly a calcifications in the carotid artery occurs which lead to narrowing or stenosis in it

CT and MRI

- CT is especially valuable in acute head injury (recent brain hemorrhage), stroke, and suspected subarachnoid hemorrhage.

In acute emergencies, CT is used rather than MRI bcz of it's availability, cost-effectiveness, rapid results + CT is enough in most acute cases

((CT scan doesn't show ischemic changes in the first 6 hrs))
BUT even in ischemic stroke, CT scan is important to exclude haemorrhage (helps the physician to decide whether it's ok to give anticoagulant..) … we can use MRI later for the characterisation of the infarction

- MRI scan demonstrate the brain using a multiplanar facility in axial, coronal, and saggital planes, with excellent views for the posterior fossa.

Use CT for detection of haemorrhage in acute events, MRI for anything else… tumours, localisation & timing of ischemic strokes, pituitary lesions >> MRI is better

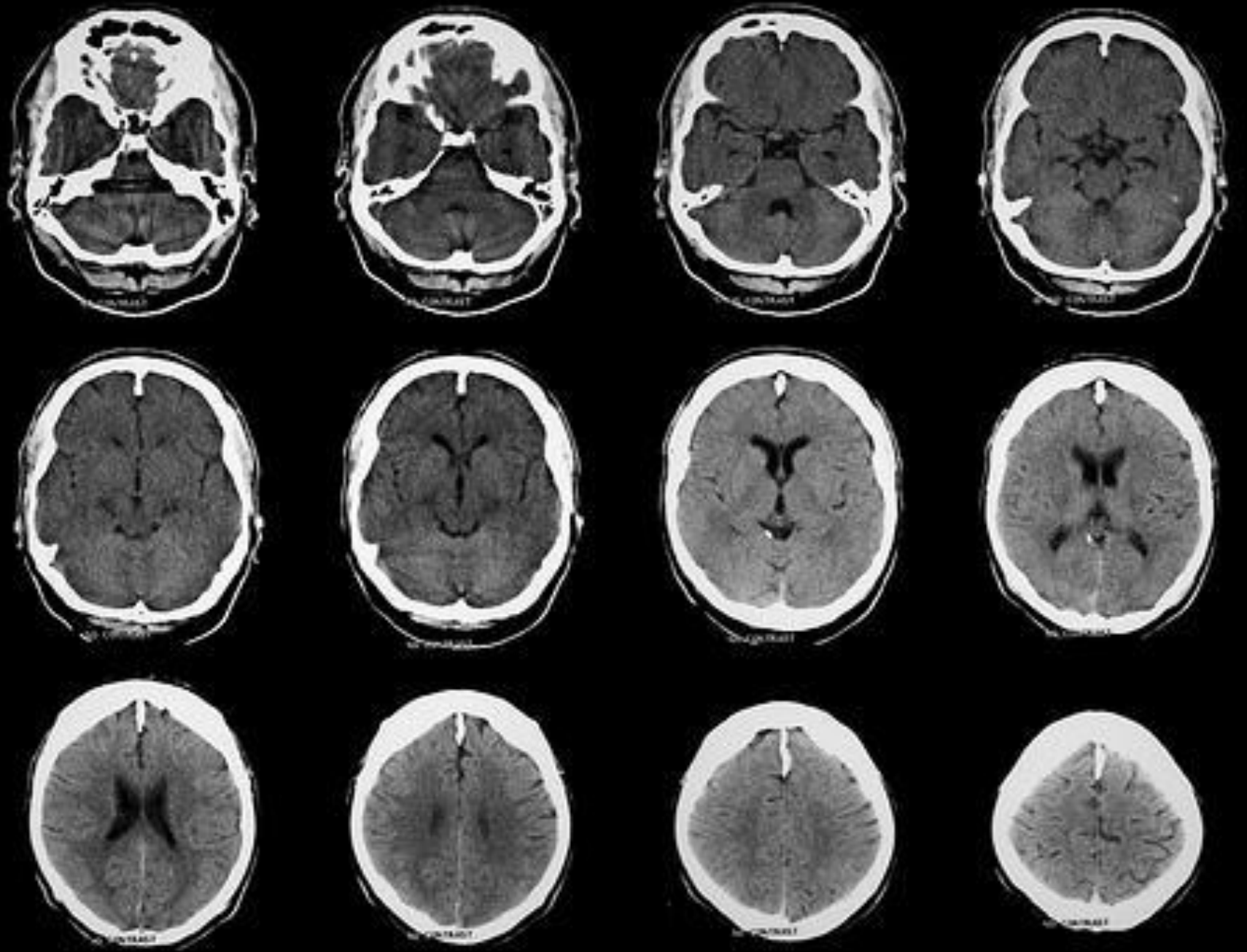
CT and MRI / 2

MRI is superior to CT in:

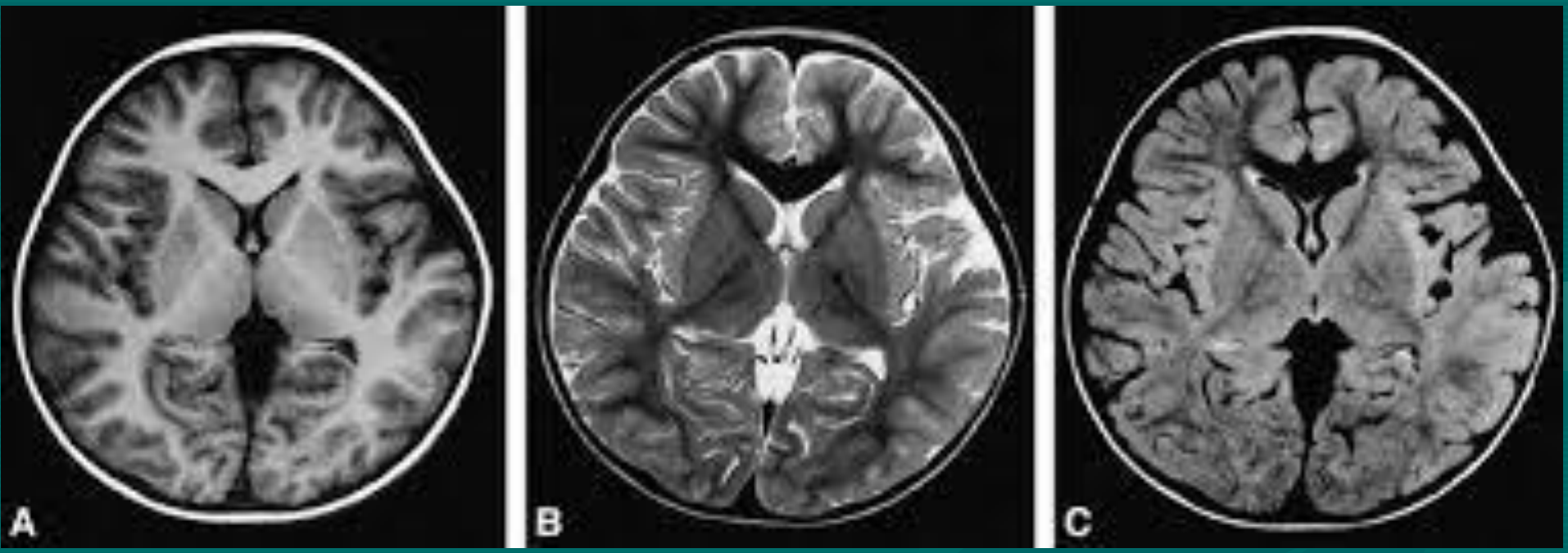
- Lesions of the pituitary fossa.
- Spinal cord abnormalities.
- White matter disease.
- Demyelinating plaques in multiple sclerosis.
- Differentiation of grey and white matter.

MRI indication:
Lesion in pituitary fossa :MRI for pituitary >>sagittal T1 with and without contrast

CT-scan, axial, normal…
Bone is hyper-dense
Fluid is hypo-dense



Normal MRI, axial



T1...
WM is white
GM is grey
Fluid is hypo-intense (black)

T2...
WM is grey
GM is white
Fluid is hyper-intense (white)

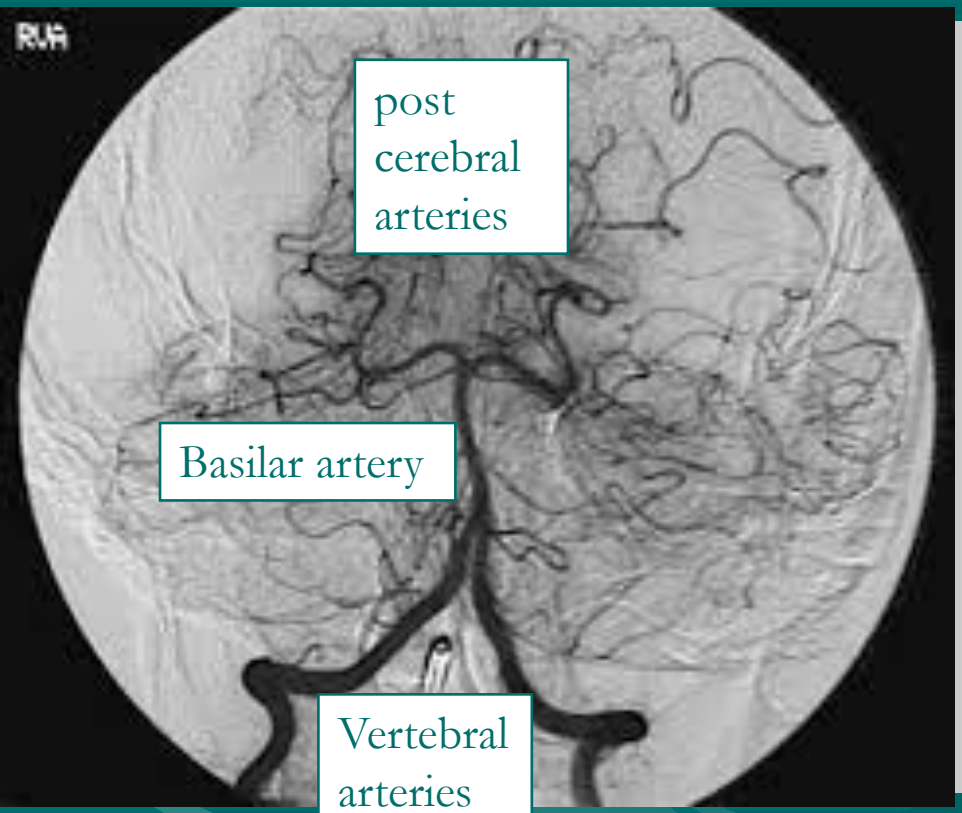
FLAIR...
WM is grey
GM is white
Fluid is hypo-intense (black)

Arteriography

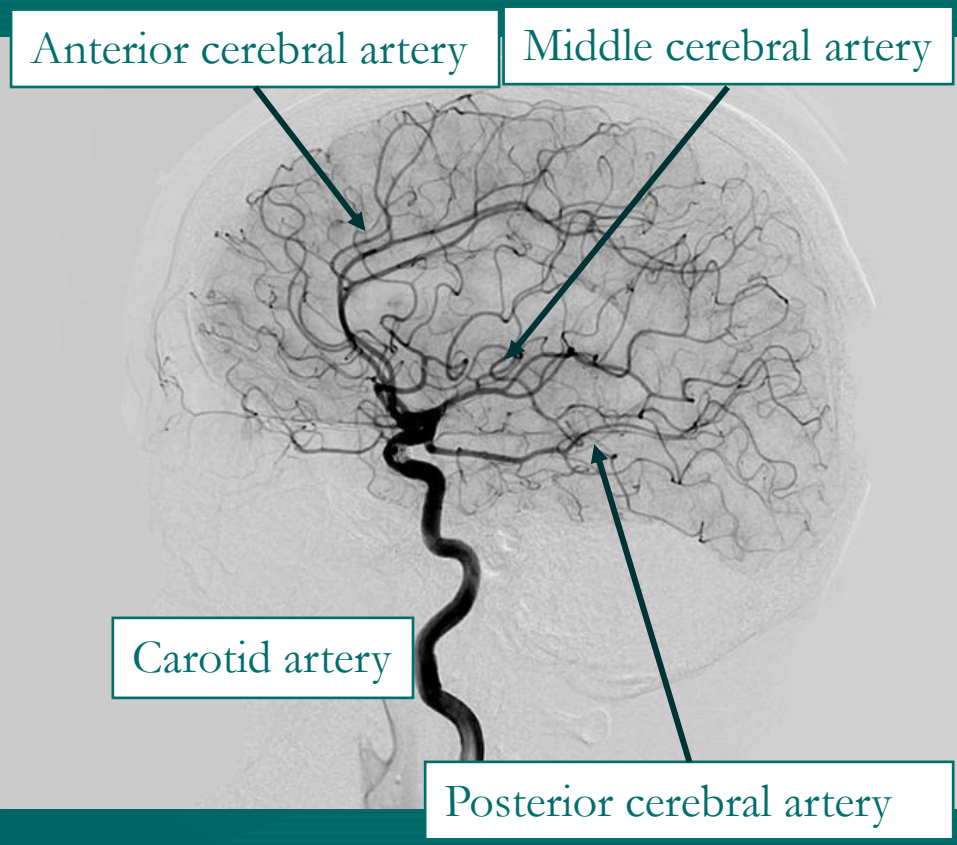
- Cerebral angiogram is useful in evaluation of aneurysm and arterio-venous malformations.
  - Arteriography … if I suspect brain aneurysm or AVM
- CTA and MRA demonstrate cerebral arterial and venous circulation and has replaced conventional angiography in many situations.

MRA can be used without contrast

The posterior circulation – coronal plane



Sagittal plane



Circle of willis can only be seen on transverse plane

BRAIN infarction

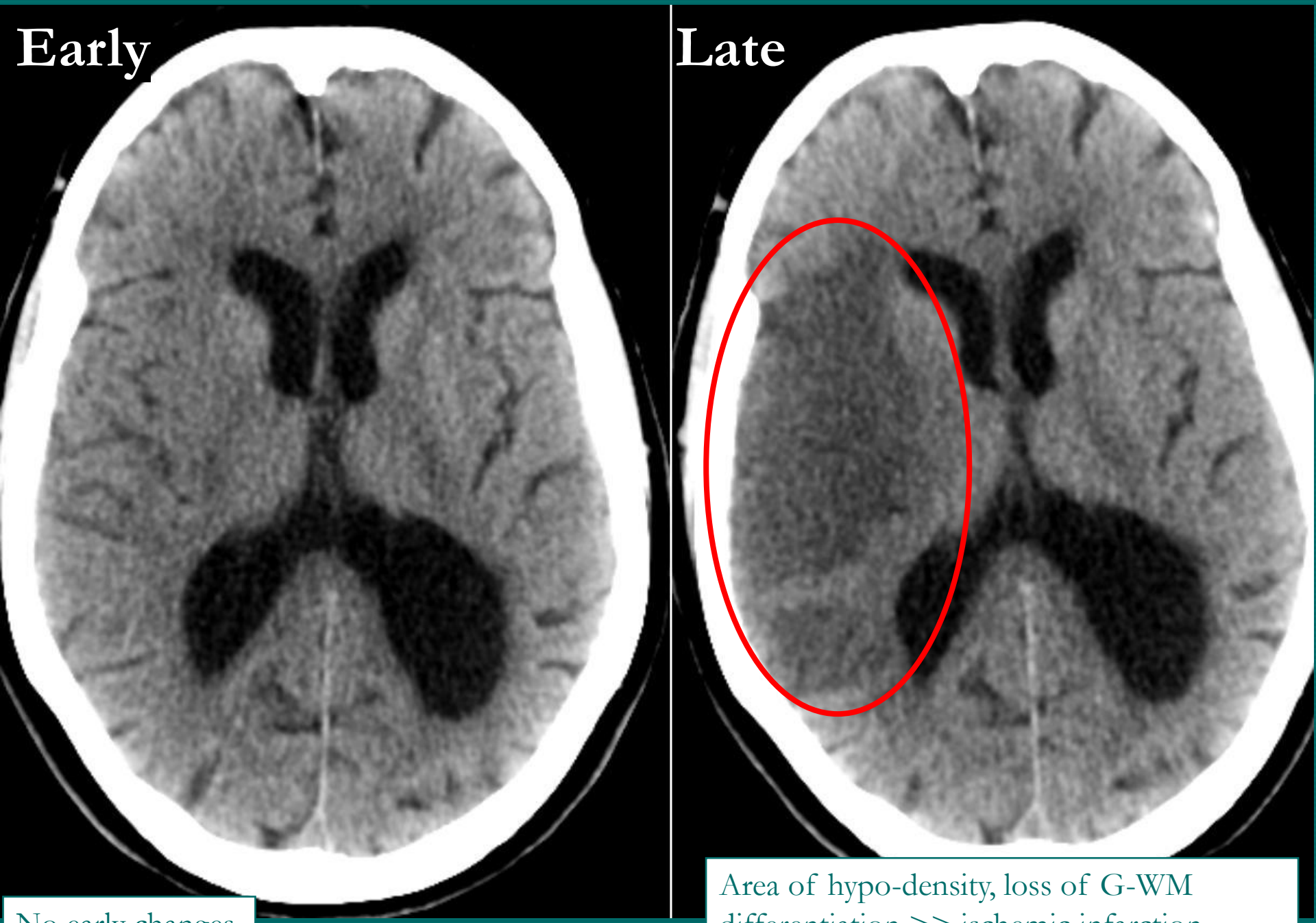
- Ischemic infarction of the brain result from interruption of the blood supply to a portion of the brain.
- The main sign of infarction is an area of decreased attenuation (hypodense) within the cerebral substance with effacement of the adjacent sulci.

- **Hemorrhage** may develop within the infarct, (about 10-15%), and is seen as an area of hyperdensity.

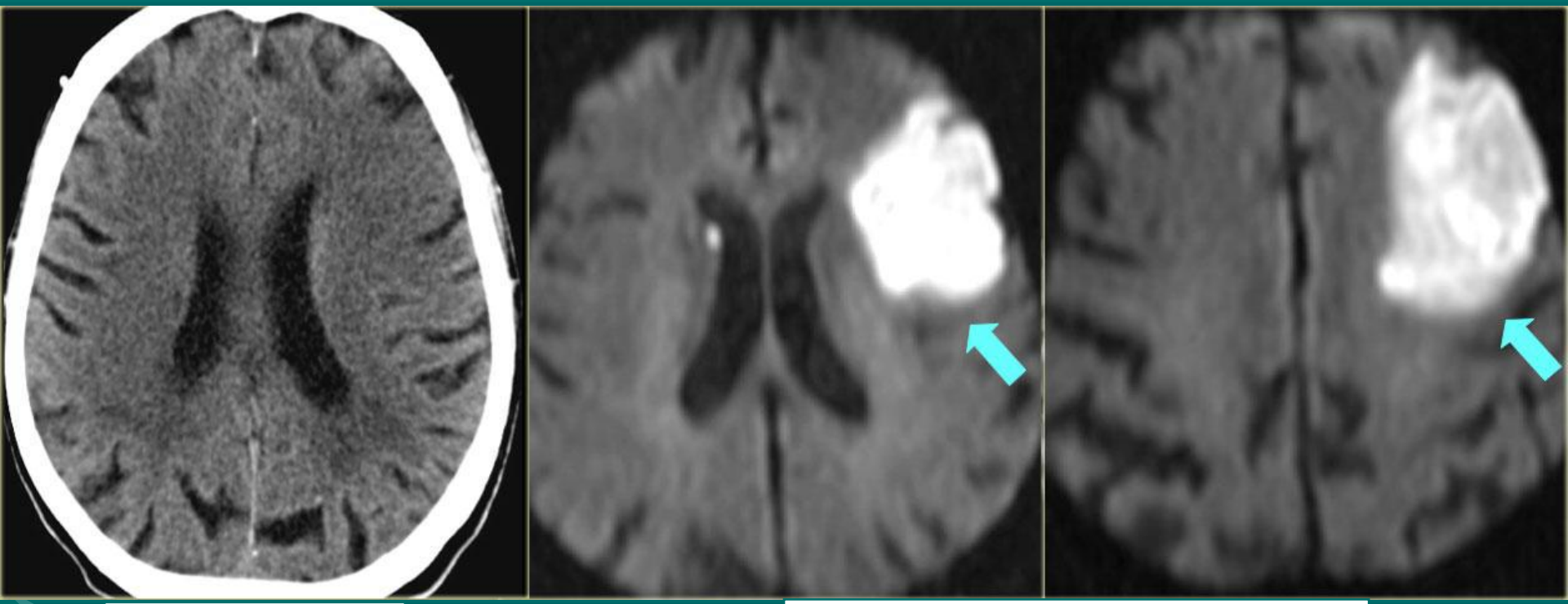
Haemorrhagic transformation>> stop the anticoagulant

Brain oedema involving the grey matter >> enlargement of GM >> loss of grey-white differentiation

Usually, the brain responds to triggers by oedema..
Ischemic infarction >> oedema >> hypo-density on CT (but these changes are late, appear after 6hrs..)
So, ischemia is hypo-dense while haemorrhage is hyper-dense


Early
Late
No early changes
Area of hypo-density, loss of G-WM differentiation >> ischemic infarction

CT vs Diffusion



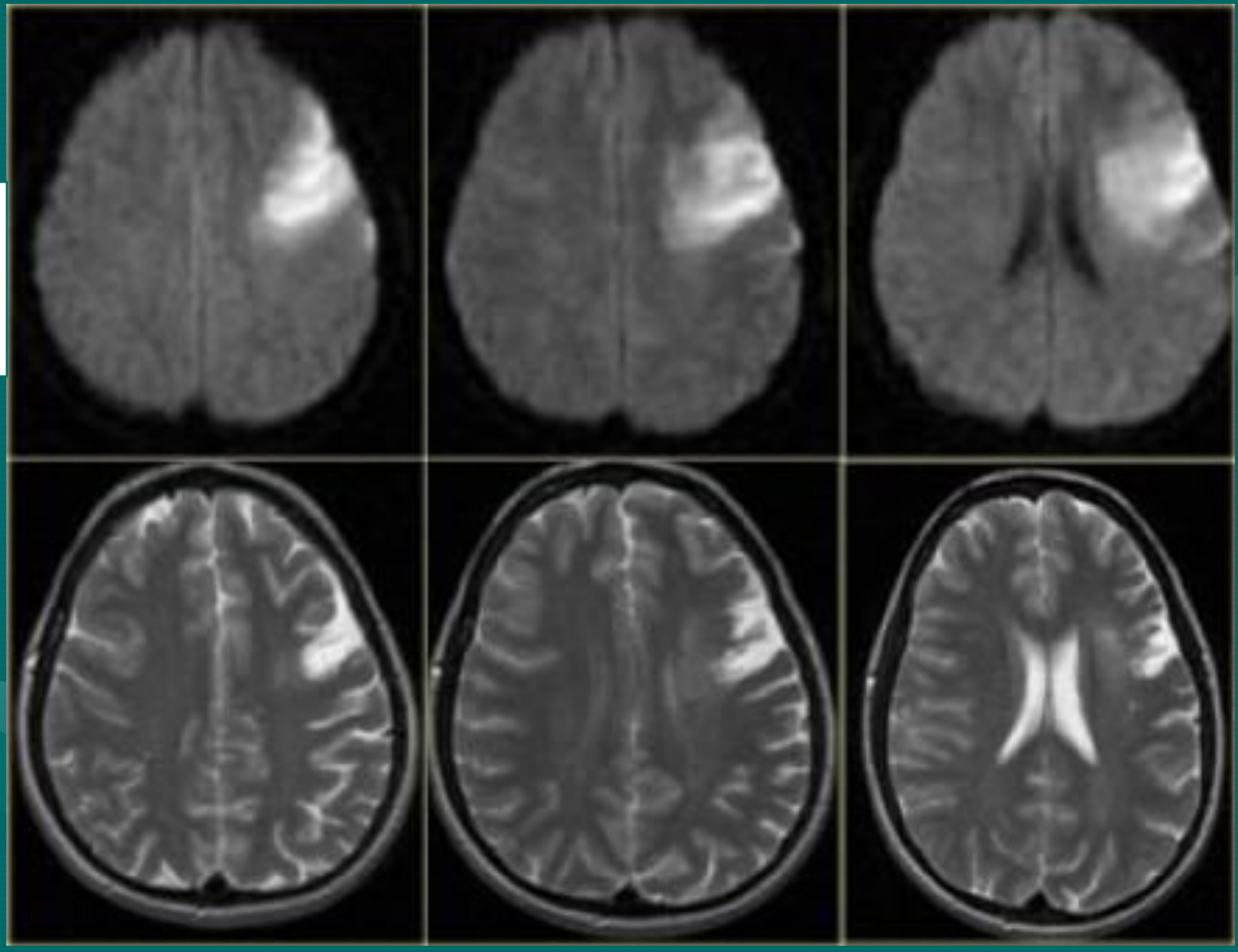
No early changes on CT

Diffusion is the most sensitive MRI sequence for detection of early ischemic changes (within minutes) >> shows areas of hyper-intensity

Important note

Diffusion

Very clear ischemic changes within mins



T2

Minimal early changes

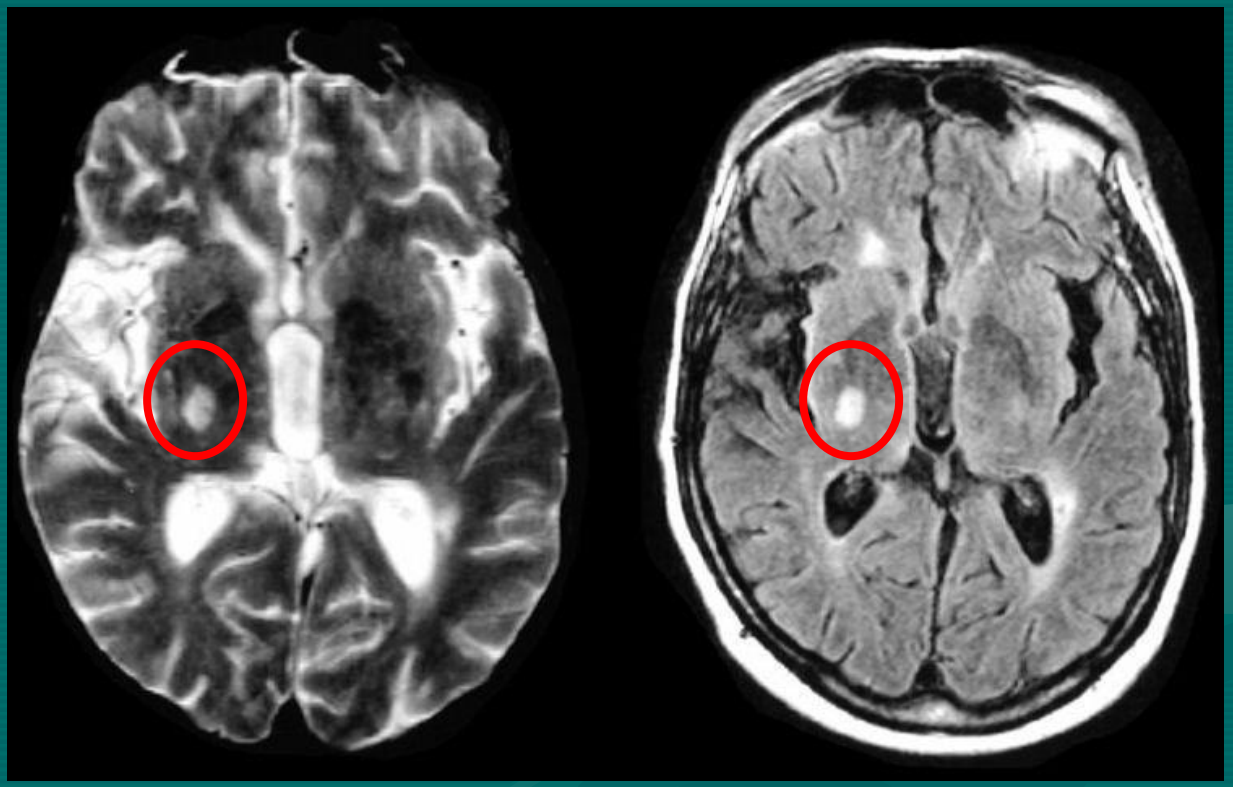
Small arteries (like perforators/thalamo-striate arteries) >> small infarcts

Lacunar infarction

- Lacunar infarcts are small, deep cerebral infarcts, occur as a result of occlusion of small distal intracerebral arteries.
- Lacunar infarcts are usually less than 1cm in diameter and appear in the region of the internal capsule, basal ganglia, thalamus and brainstem.
- Lacunar infarcts are commonly seen in patients with small vessel disease.

Small vessel dzs: HTN/DM/small vessel vasculitis

CT scan.. Late ischemic changes



MRI diffusion ??

CT and MRI in brain infarction

Why CT is the modality of choice for the initial evaluation of stroke ?

- CT is superior to MRI in detecting recent brain hemorrhage, and the role of CT is to exclude the presence of intracerebral hemorrhage, because the treatment of an infarct will differ depending on whether hemorrhage is present or not.
- MRI is superior and more sensitive than CT in the evaluation of any kind of edema and for the detection of acute infarction.

Brain hemorrhage

- Intracerabral hemorrhage:

  Is bleeding in the brain caused by rupture of a blood vessel.

Usually takes the shape of the structure affected

- May occur in any part of the brain, but the frequent sites are: basal ganglia, thalamus and cerebellum.
- A third of intracerebral bleeds result in intraventricular hemorrhage.
- **Most common causes are:**

  - Chronic hypertension
  - Rupture aneurysm or arterio-venous malformation

Usually affects basal ganglia, brainstem, cerebellum..
Usually taking the shape of these structures

You need to determine the cause for the management
HTN >> treated medically
Aneurysm/AVM >> treated surgically

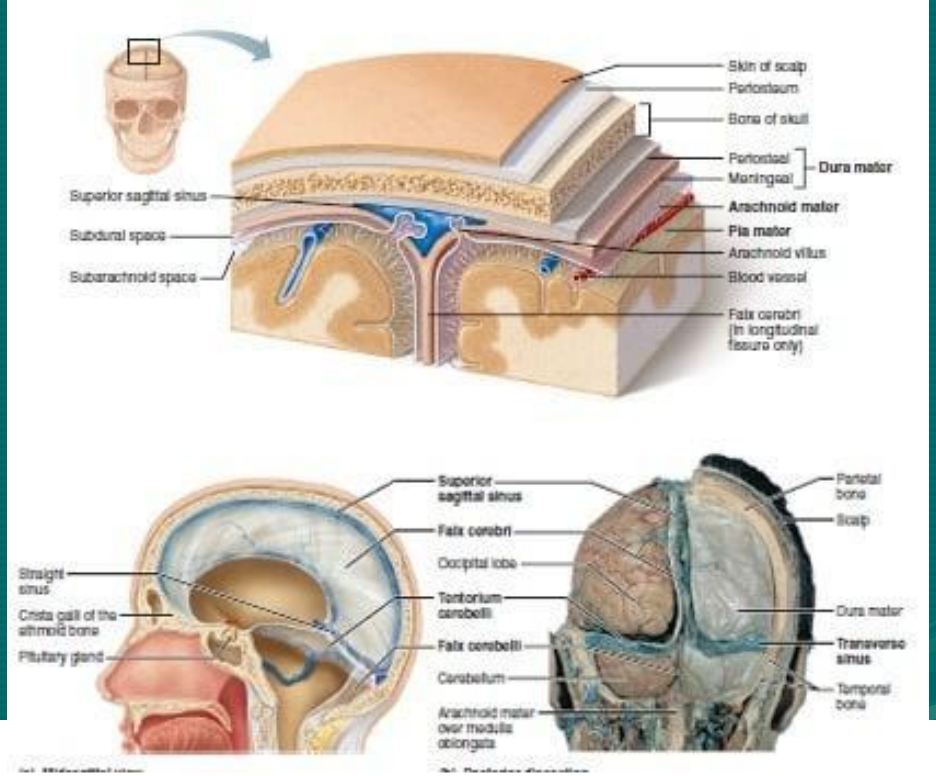
On CT scan >> haemorrhage is hyper-dense acutely, (hypo-dense later?)

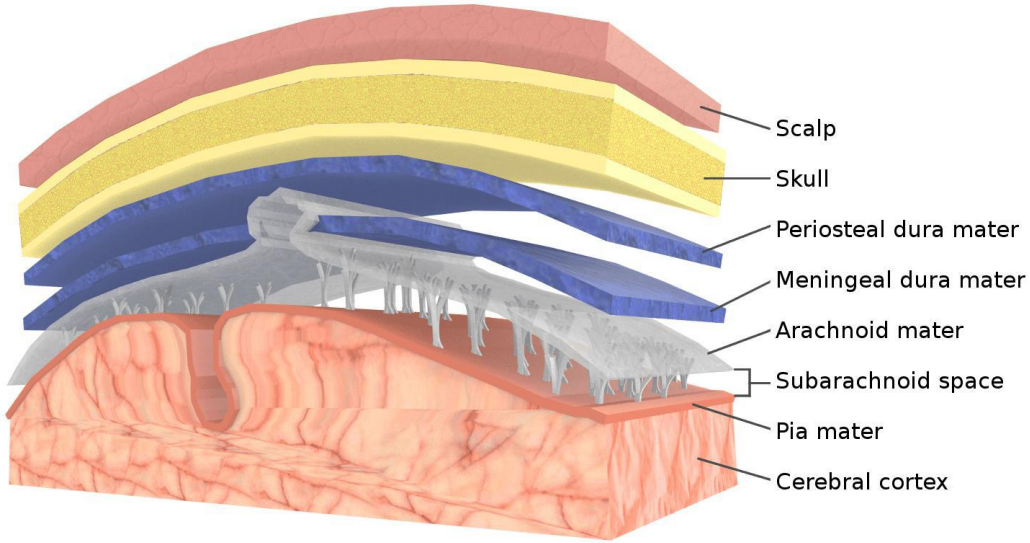
• Intracerebral hemorrhage

CT scan
Haemorrhage is hyper-dense.. Taking the shape of basal ganglia >> HTN

Intracranial Hematomas Head injury

- Intra parenchymal hematoma
- Epidural hematoma
- Subdural hematoma
- Subarachnoid hemorrhage


Skin of scalp
Periosteum
Bone of skull
Periosteal
Meningeal
Dura mater
Arachnoid mater
Pia mater
Arachnoid villus
Blood vessel
Falx cerebri (in longitudinal fissure only)
Superior sagittal sinus
Subdural space
Subarachnoid space
Superior sagittal sinus
Falx cerebri
Occipital lobe
Tentorium cerebelli
Falx cerebelli
Cerebellum
Arachnoid mater over medulla oblongata
Straight sinus
Crista galli of the ethmoid bone
Pituitary gland
Parietal bone
Scalp
Dura mater
Transverse sinus
Temporal bone


Scalp
Skull
Periosteal dura mater
Meningeal dura mater
Arachnoid mater
Subarachnoid space
Pia mater
Cerebral cortex

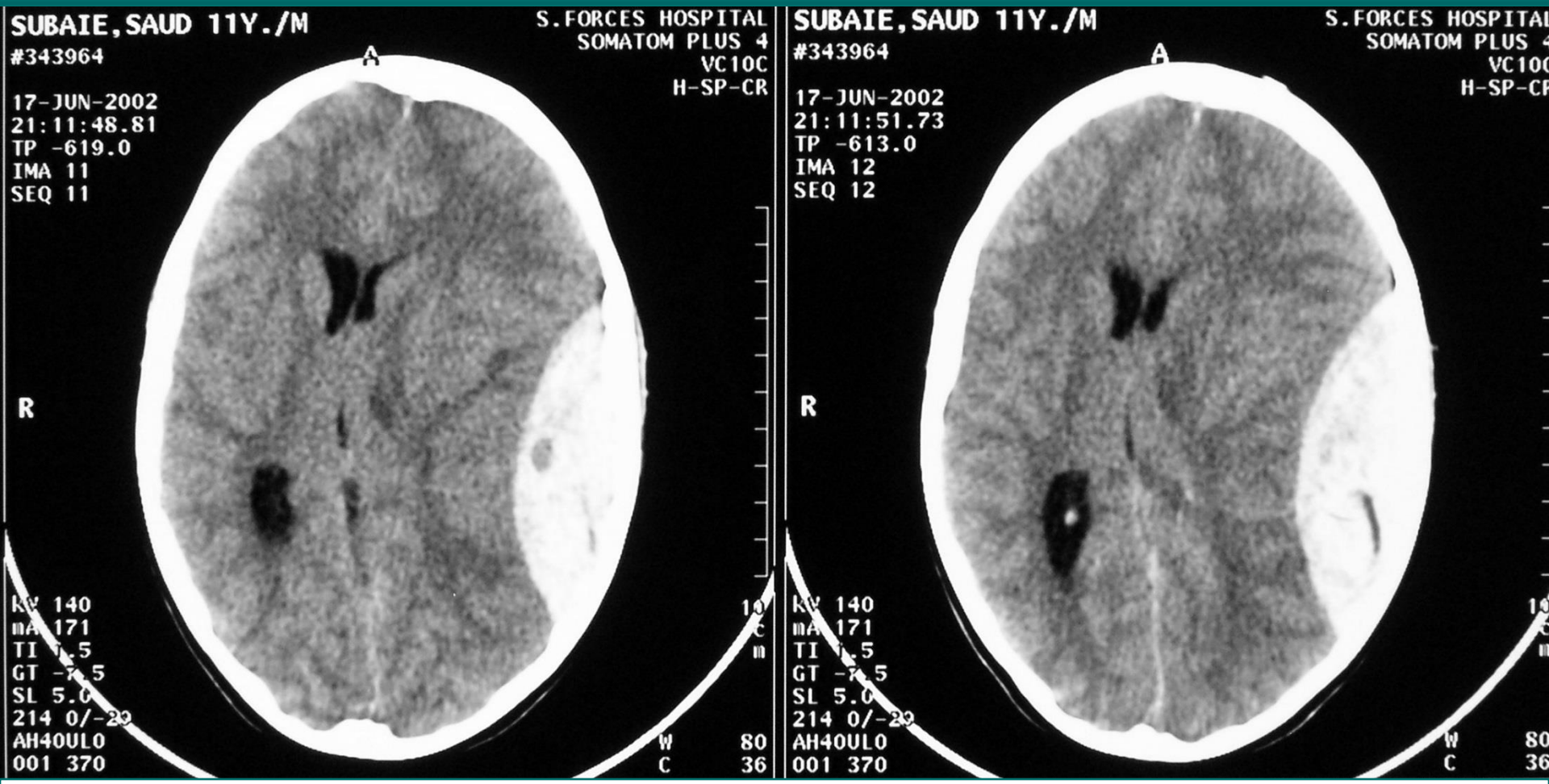
Epidural Hematoma

- Collection of blood between the inner table of the skull and the dura
- Most often occurs as a result of an arterial injury, usually middle meningeal artery or one of its branches, and therefore are usually temporo-parietal in location.
- The typical CT appearances of epidural hematoma is biconvex or lenticular, high density lesion.

Dura is attached to sutures >> epidural haematoma is limited in that space >> appears biconvex
It's usually caused by fractures/trauma
Blood is arterial
Most commonly temporo-parietal

Haemorrhage is typically homogenous
Sometimes it's not >> SWIRL SIGN
Since the space is limited, and blood is arterial in origin (there's a high blood flow) >> blood swirls within this space
These swirls appear as hypo-dense areas within the hyper-dense are of haemorrhage

Epidural haemorrhage – arterial blood – high blood flow – actively bleeding lesions >> this may eventually cause herniation



This is brain CT scan, ventricular level, young male pt.. Well defined biconcave hyperdense area in the parieto-occipital lobe of the left side causing shifting of the midline to the right side and compression of the left-side structures. It is epidural haematoma

Subdural Hematoma

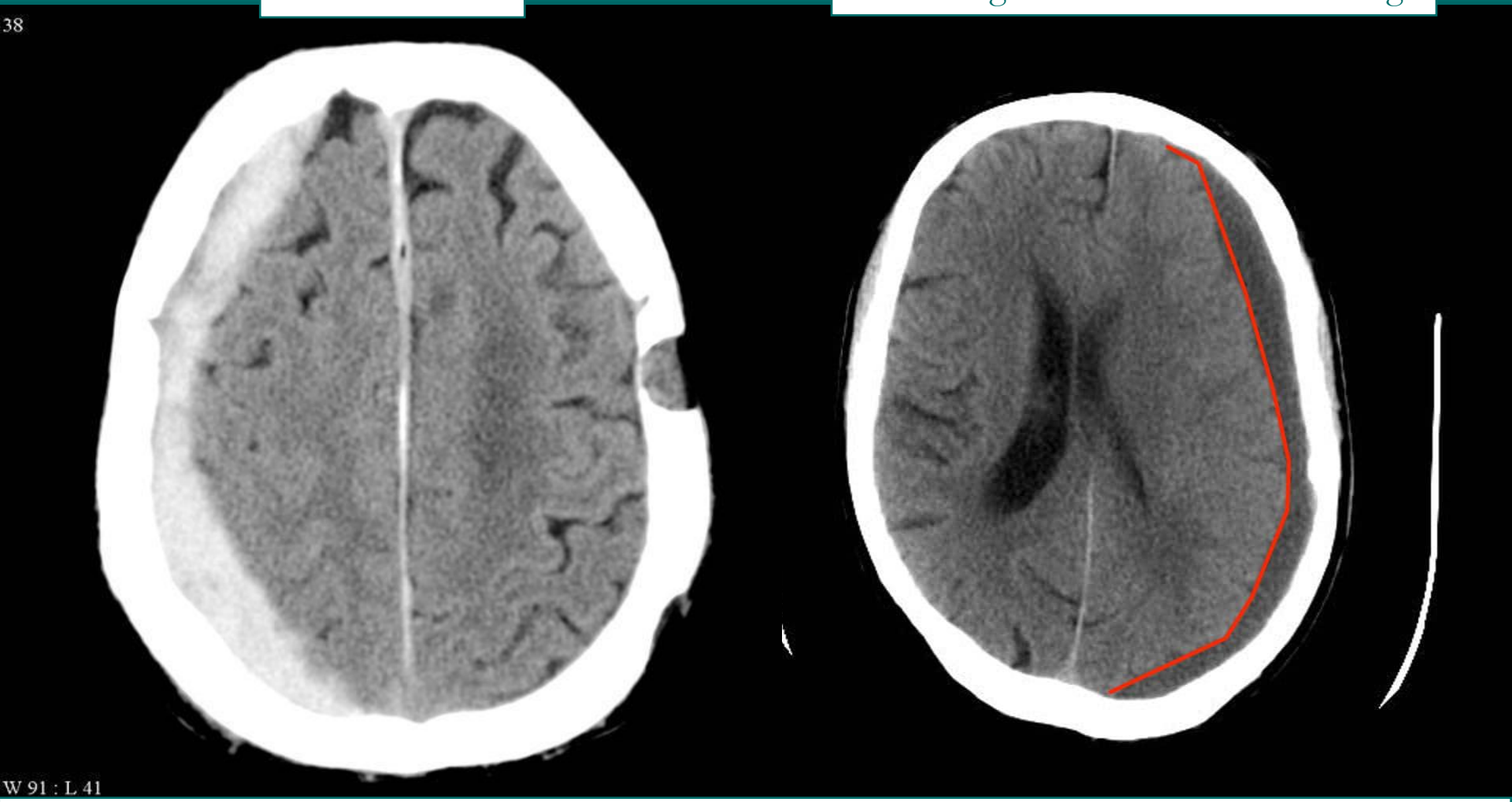
- Collection of blood between the dura and arachnoid
- Result from venous injury, usually tear of the bridging cerebral veins within the subdural space.
- The characteristic appearance of acute subdural hemaotma on CT is hyperdense crescent-shaped collection with concavo-convex configuration.

Occur in extremity of ages very old or very young
Very old: have brain atrophy and stretched veins may be spontaneous or due to minor trauma
In young, maybe a major trauma
Usually not related to fractures
Blood is venous
Not limited by the sutures >> crescent shape

in acute: hyperdense crescent shape
in chronic : hypodense due to liquefaction; all cells becomes in fluid status (bcz it's venous blood)
as patient is lying on bed so cells and fluid accumulate posteriorly >> the hematoma appears more hypo-dense anteriorly but more hyper-dense posteriorly

Acute subdural

Late changes of subdural haemorrhage

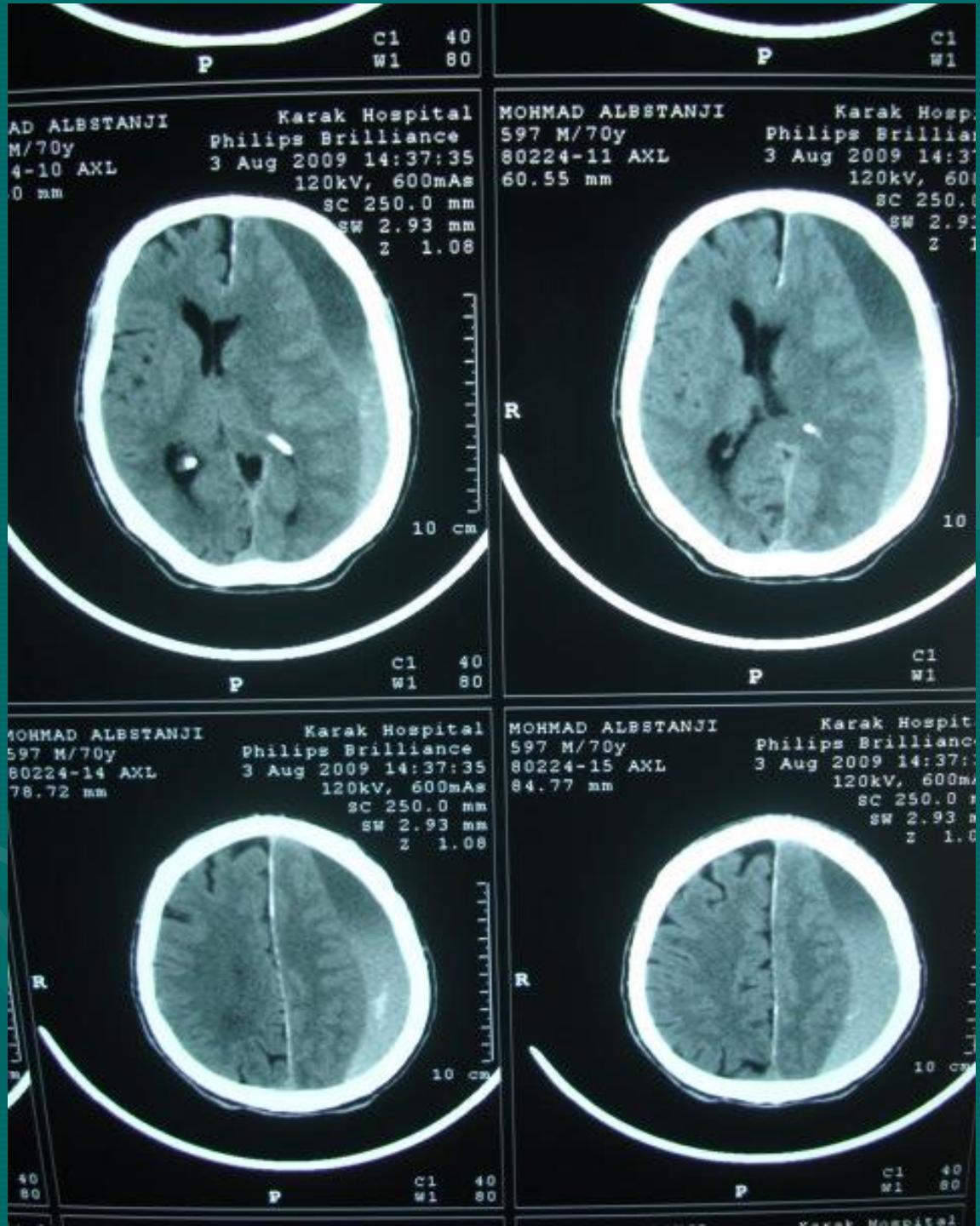


Epidural vs subdural haematoma…

Epidural must be immediately referred to tertiary centre with neurosurgery unit.. Bcz the blood is arterial (high flow) it may rapidly deteriorate.. Pt must be continuously monitored there, since at any moment a surgery may be required..

While subdural haematoma is venous, should be referred but we're not as much in a hurry.. Since it may progress rapidly but may also stop with proper medications and monitoring

Also subdural - late



Subarachnoid Hemorrhage

- Hemorrhage into the CSF spaces, and frequently present in the acutely injured patient.
- SAH appear as hyperdensities filling the CSF spaces (basal cisterns, cerebral sulci, sylvian fissures and interhemispheric fissure).
- Subarachnoid hemorrhages are most often the consequence of penetrating injury, rupture aneurysm and systemic hypertension.

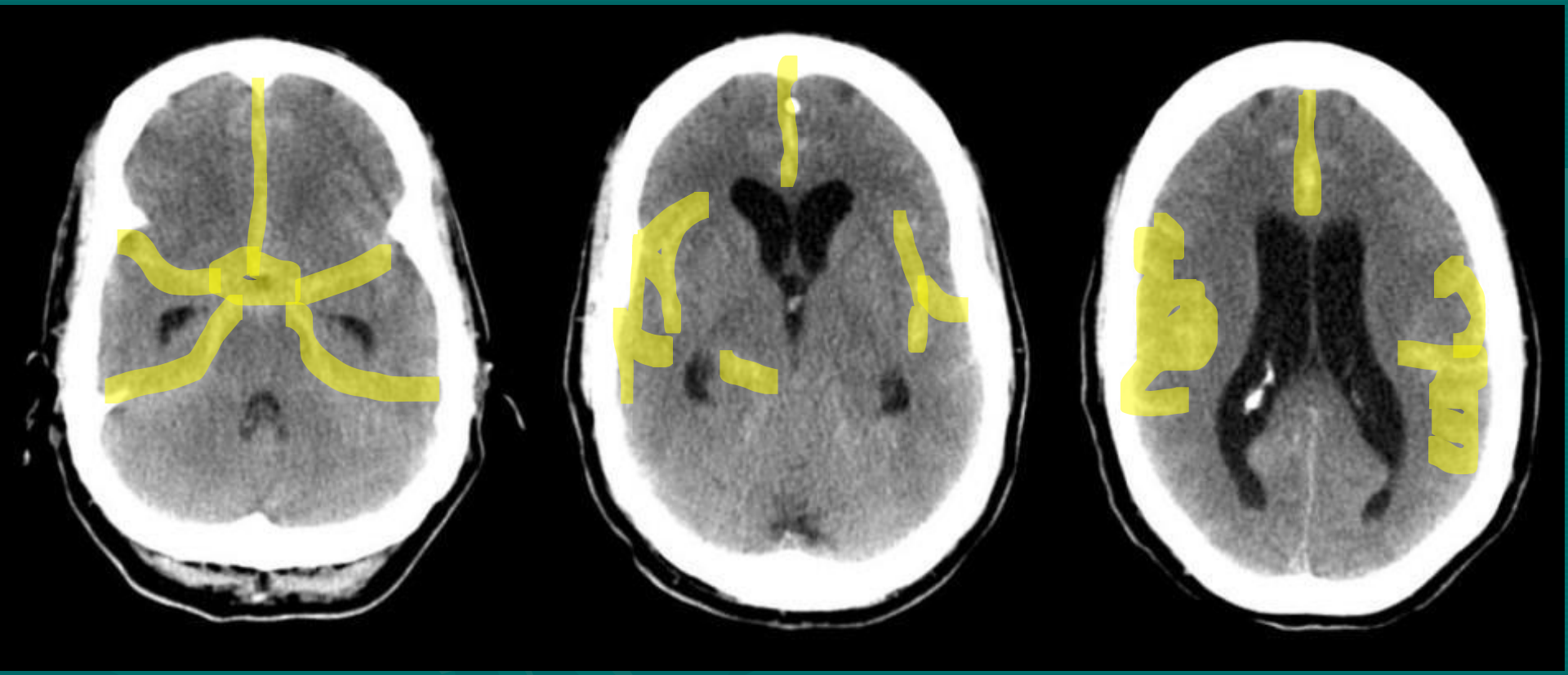
Most common cause is traumatic (penetrating injury)
But most common non-traumatic is rupture aneurysm

Best seen using MRI T2 star sequence (hypo-intense).
But it's quite expensive and not always available..

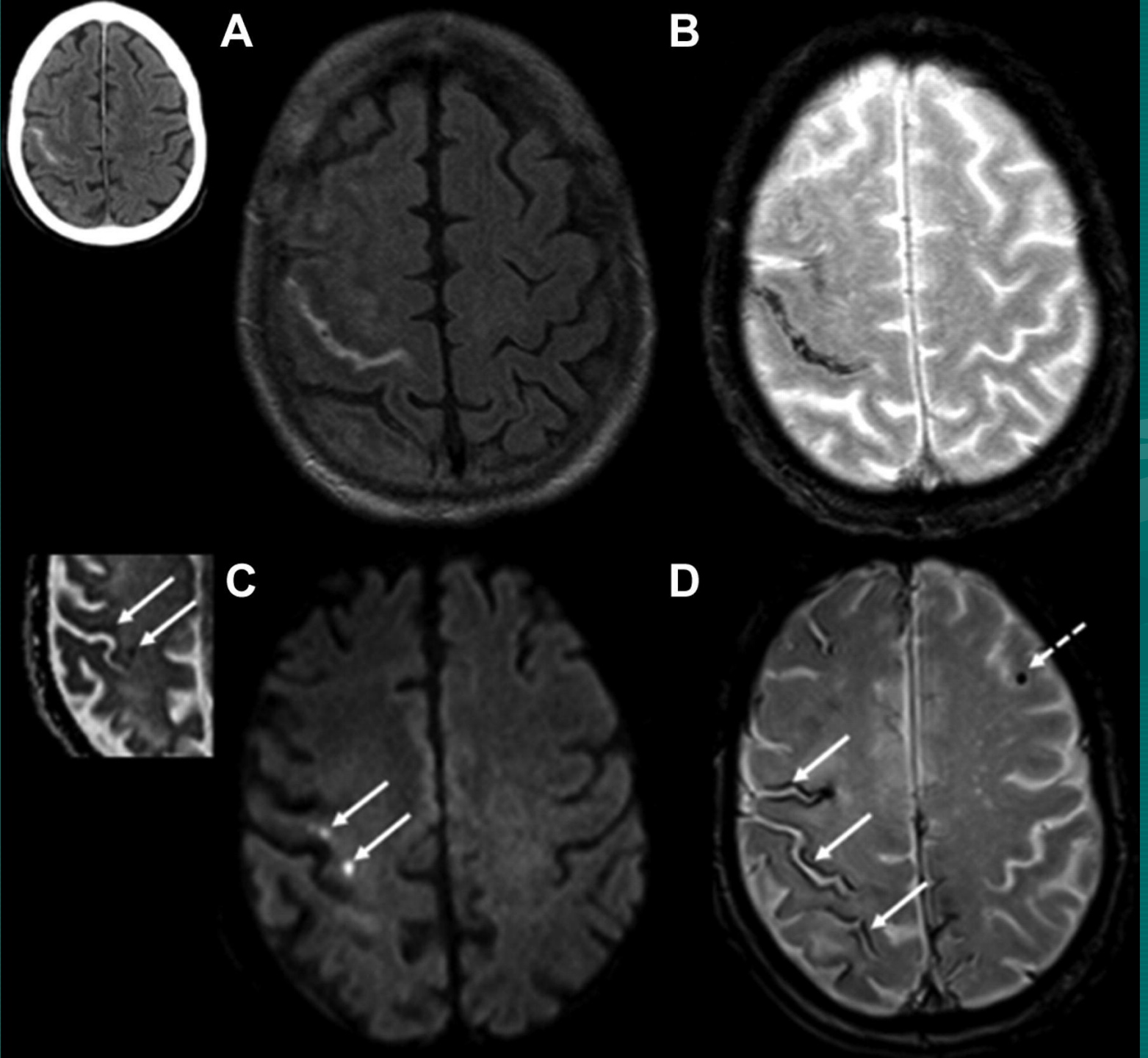
Signs of SAH: vomiting ,meningeal(sings like neck stiffness) sever sudden headache

On CT, CSF spaces normally appear hypo-dense.. In SAH, you find areas of hyper-density

Muti-axial CT, multiple areas of hyper-density filling the sulci



http://casemed.case.edu/clerkships/neurology/Web%20Neurorad/SubarachnoidHemorrhage3.htm



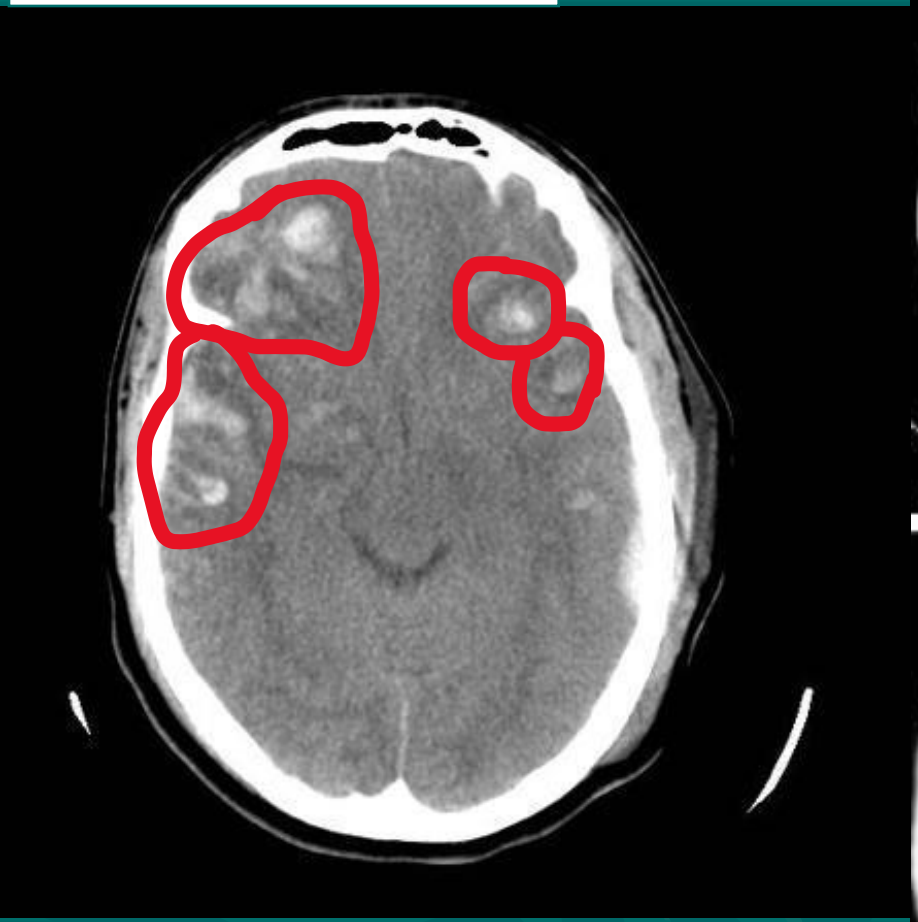
MRI

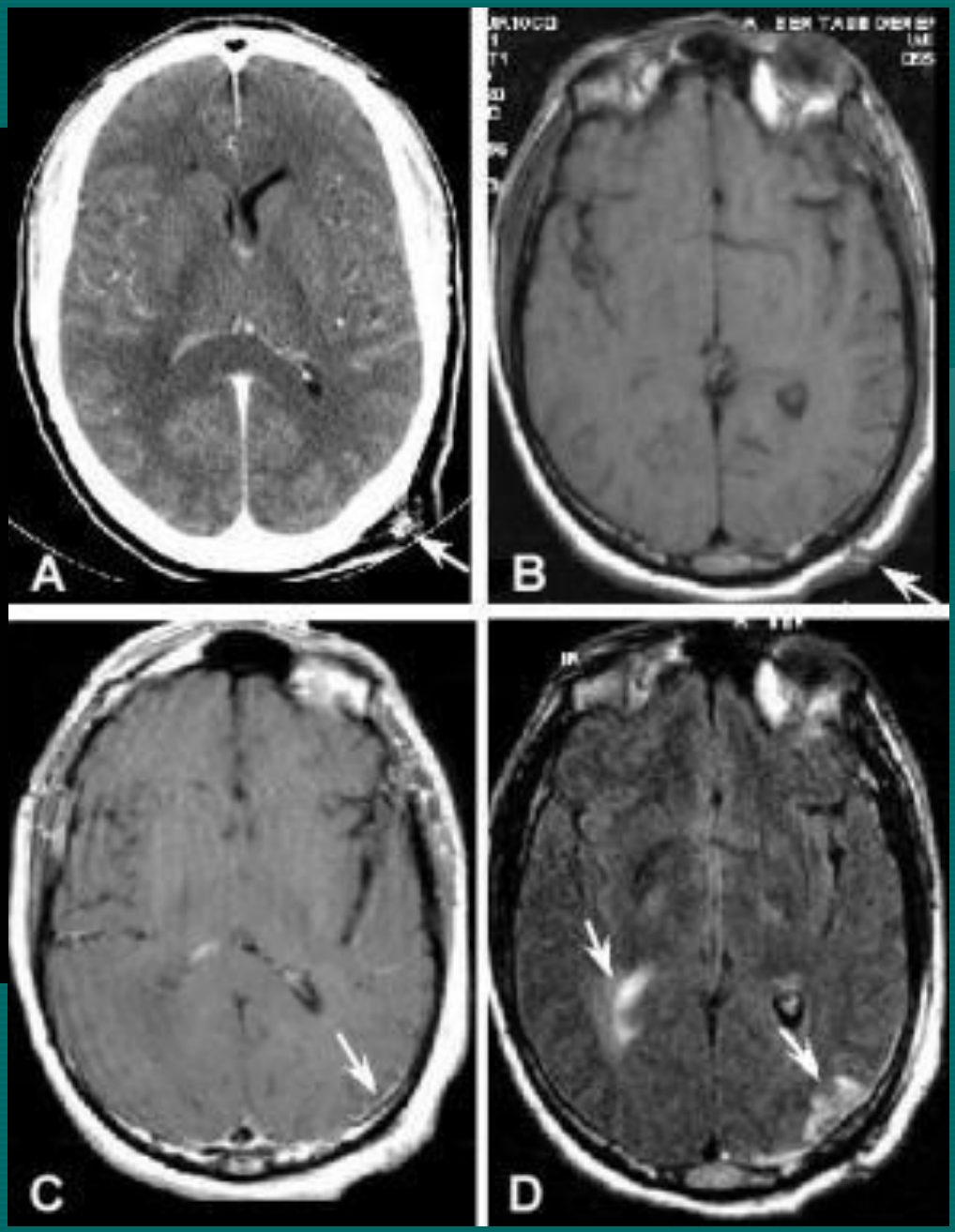
Cerebral Contusion

- Bruising or crushing of brain tissue.
- Two types of cerebral contusion:
  * nonhemorrhatic (necrotic)
  * Hemorrhagic
- The hemorrhagic areas may not be evident in the very acute stage or in the first 24 hours.

Usually due to acceleration-deceleration like car accidents >> shearing of axons >> brain respons to triggers by oedema >> multifocal areas of hypo-density on CT >> within these areas there may be haemorrhage (haemorrhagic contusions) >> areas of hyper-density within hypo-density

Hyper- within hypo-density





The most common WM dz

Multiple sclerosis (MS)

- **MS is a white matter disease**, affects areas of the brain and spinal cord, destroying the fatty layer (the myelin sheath) which wraps around nerve fibers, resulting in areas of demyelination.
- Most common in young people and about two thirds of patients are female.
- The demyelinating lesions (plaques) present with a characteristic relapsing and remitting course.

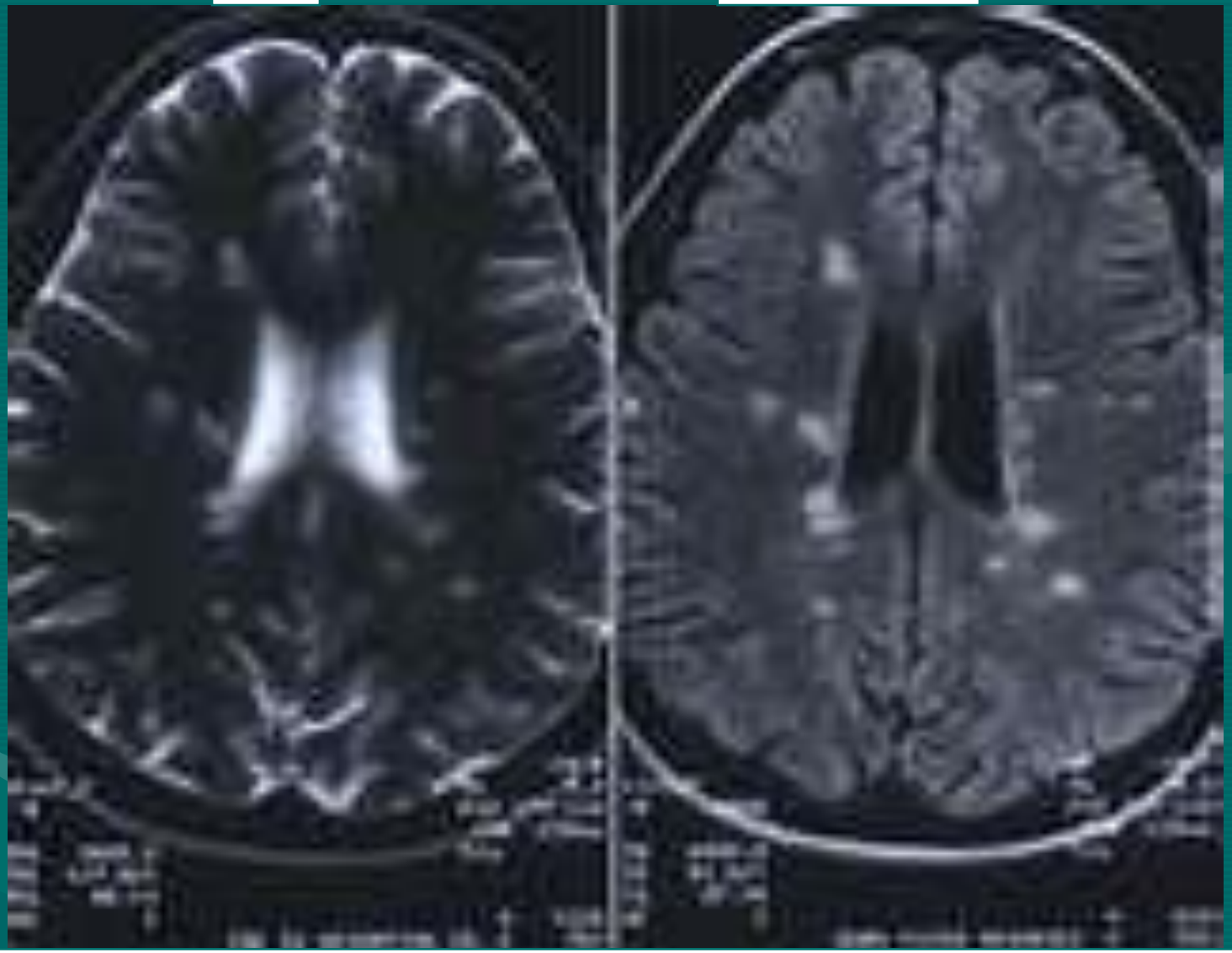
CT may not show lesions.. we should also do MRI for spinal cord.
-Hyper-intensty lesions in the deep white matter/ subcortical white matter mostly periventricular and perpendicular to the lateral ventricles
-Flair is the best sequence.. used with contrast to detect active lesions this is important in follow up during treatment

Multiple sclerosis / 2

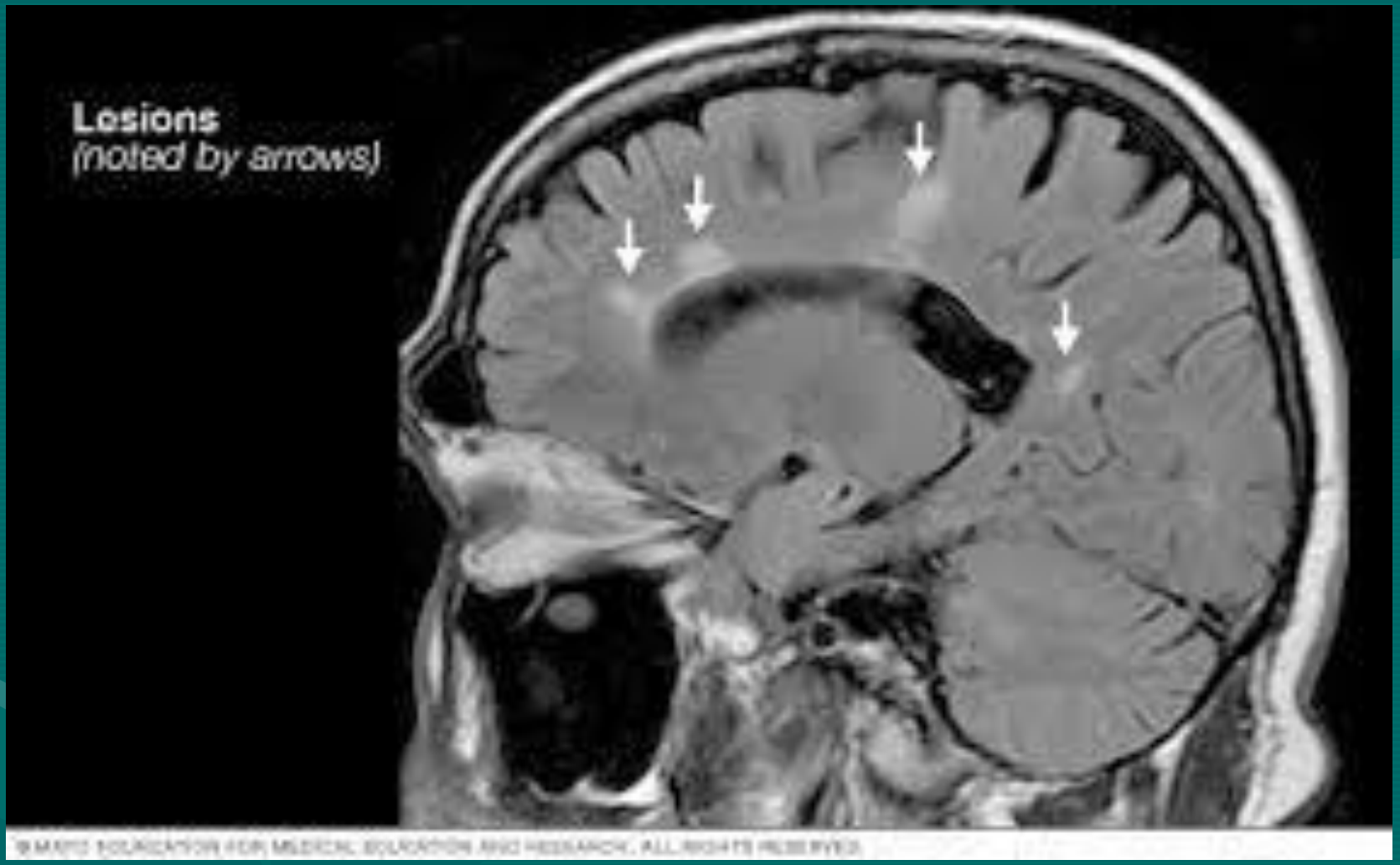
- **MRI is the investigation of choice.**
- The demyelinating plaques appear as focal discrete areas of abnormal high signal intensity on T2-weighted images.
- The common location of plaques are in the periventricular region, corpus callosum, and to a lesser extent in the brain stem, cerebellum, optic nerves and in the spinal cord.
- Contrast enhancement of the plaques indicate active disease.

T2

T2 - FLAIR



On T2, both CSF and the lesions are hyper-intense >> we may miss the lesion
That's why FLAIR is the sequence of choice for MS, as it supresses the CSF so we can see the lesions more clearly


Lesions
(noted by arrows)

Brain Tumors

Metastasis can be intra- or extra- axial

Primary brain tumors can be classified as:

Intra-axial tumors:

arising in brain parenchyma.

Extra-axial tumors:

arise from cells outside the brain, such as the meninges and cranial nerves.

Most common primary brain tumours in adults : Supratentorial tumours
Most common primary brain tumours in children : infratentorial tumours
Tumours can be seen without contrast but we always use it to intensify the picture(low grade tumours there is no enhancement but grade 4 there is enhancement)

Brain tumors / 2

GLIOMAS:

More than 50% of primary intracranial tumors are gliomas, and constitute a heterogenous group of tumors including:

- Astrocytomas.
- Ependymomas.
- Oligodendrogliomas.

Astrocytomas

- Arise from astrocytes
- Graded into four grades depending on the severity and prognosis (grade I favourable prognosis and grade IV worst prognosis)
- The low grade astrocytomas are most commonly in young adults.
- The high grade astrocytomas (grade 1V) are called glioblastoma multiforme.

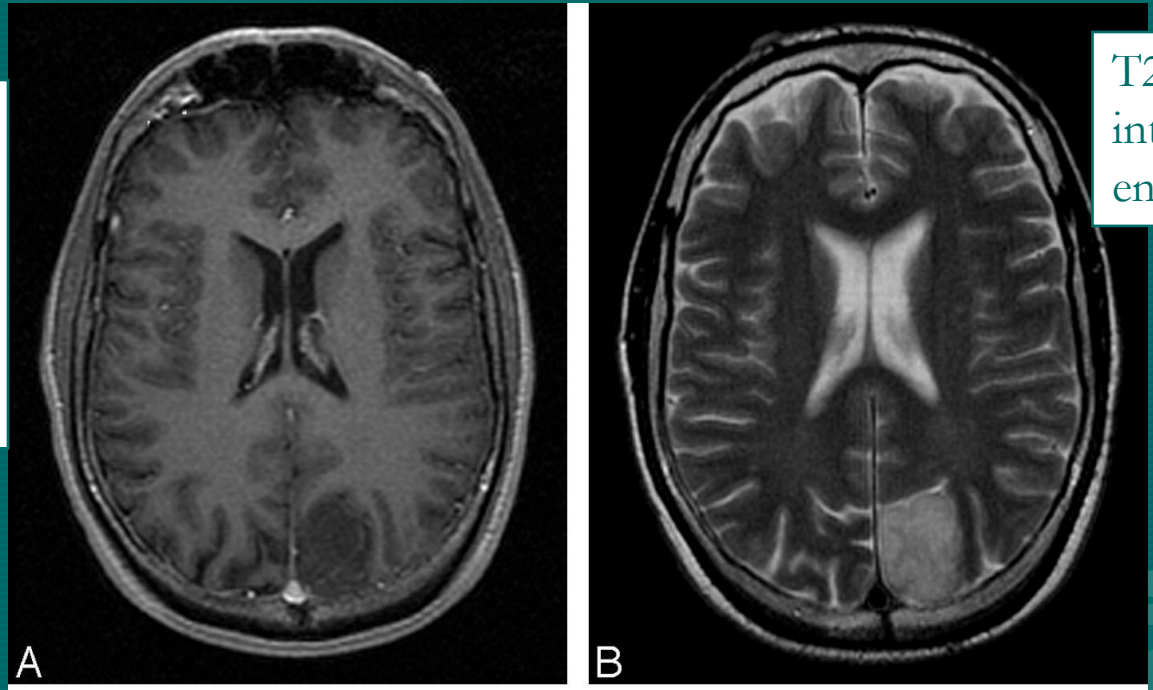
MRI is the best for brain tumours but we can use CT scan. Low grade gliomas on CT appear as areas of hypodensity.. With no contrast enhancement & no oedema..

Areas of hypodensity could be infarction or tumour – diagnosis depends on history
Acute onset of weakness/paraesthesia >> probably infarction
History of headache for a long time>> tumour

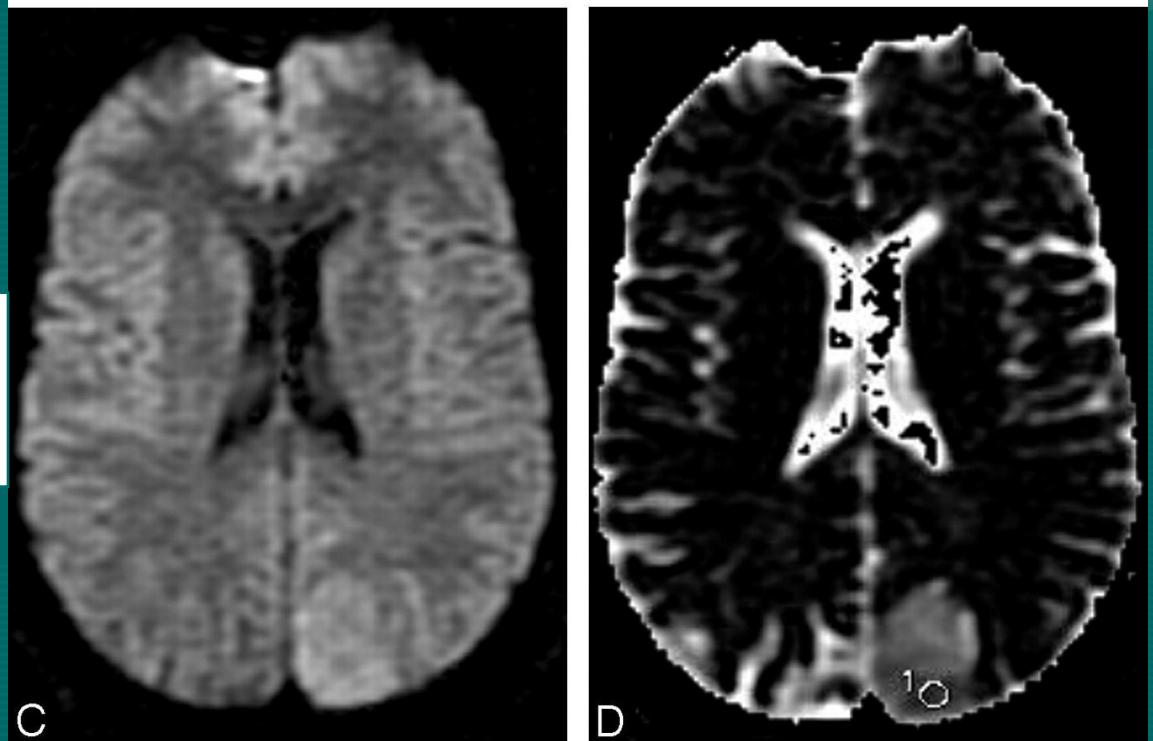
-the superior sagittal sinus with contrast is enhanced so there is no thrombosis if its not enhanced it will give empty delta sign
-NEXT STEP is MRI

contrast CT shows low grade tumor- no shift, no enhancement, not haemorrhage, lesion is well defined

T1.. Hypo-intense.. No contrast enhancement.. Well-defined, no oedema >> low-grade glioma

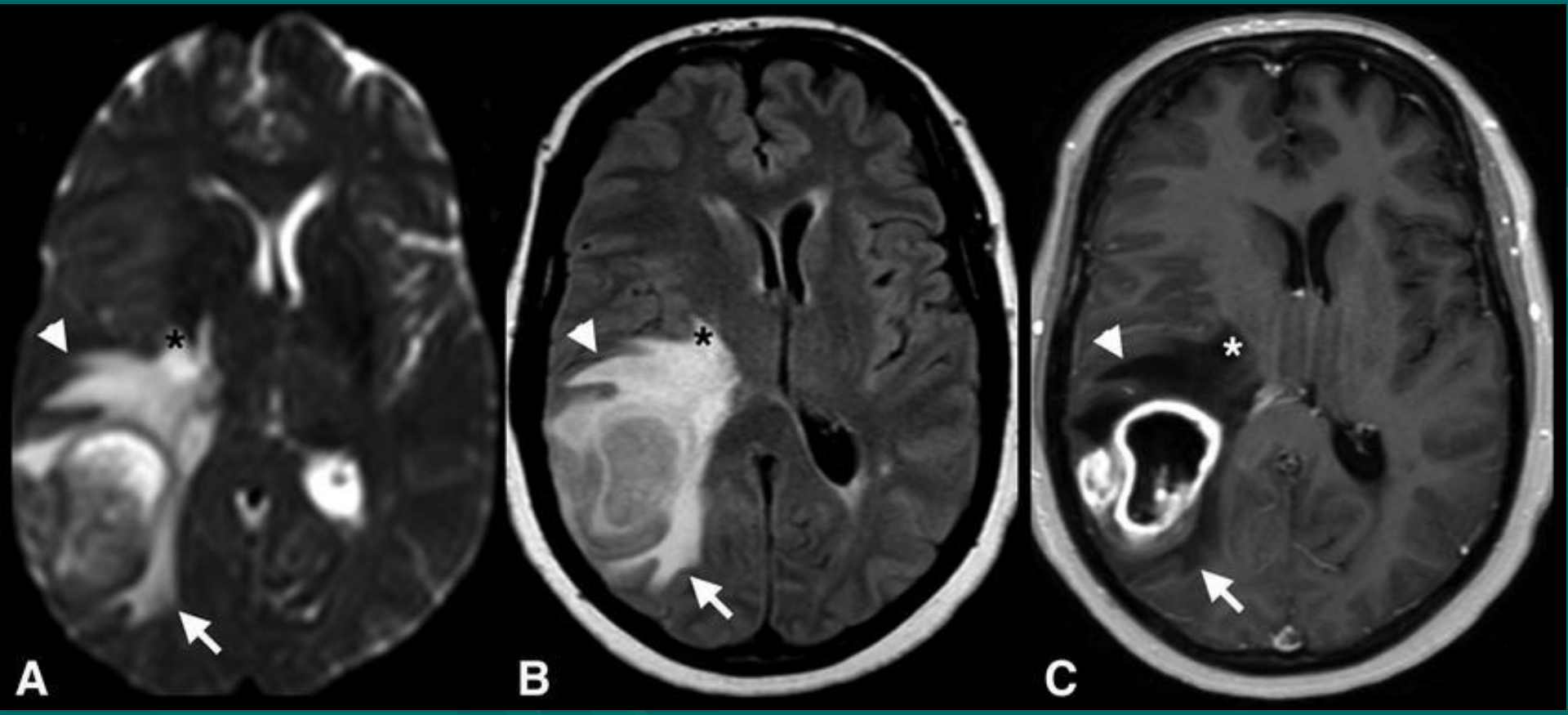


T2>> hyper-intense, no enhancement

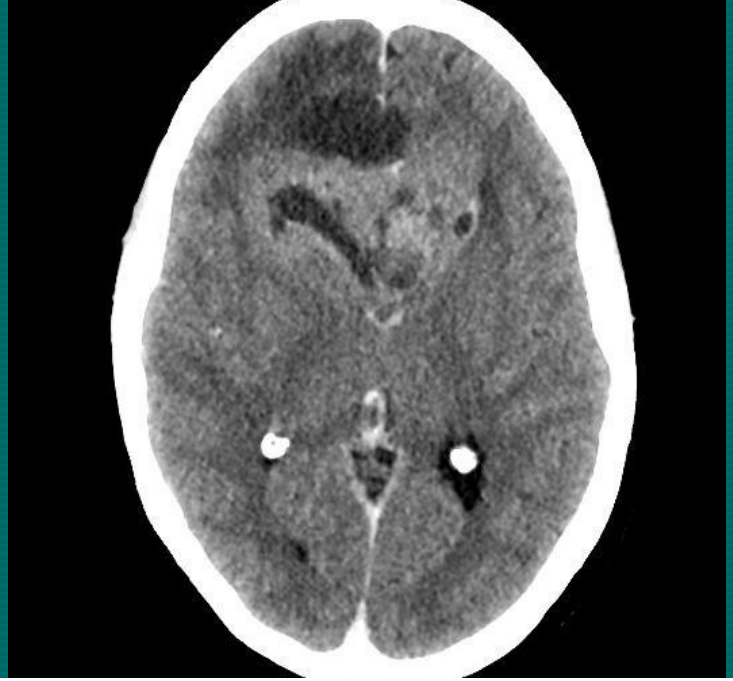


FLAIR>> hyper-intense, no enhancement

GBM

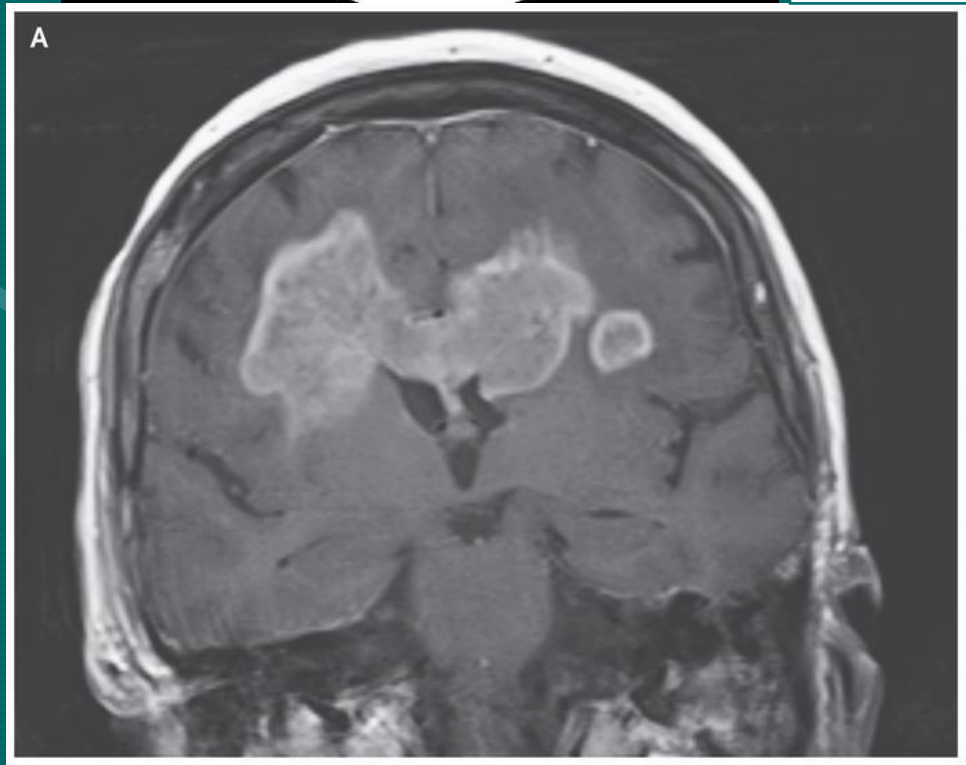


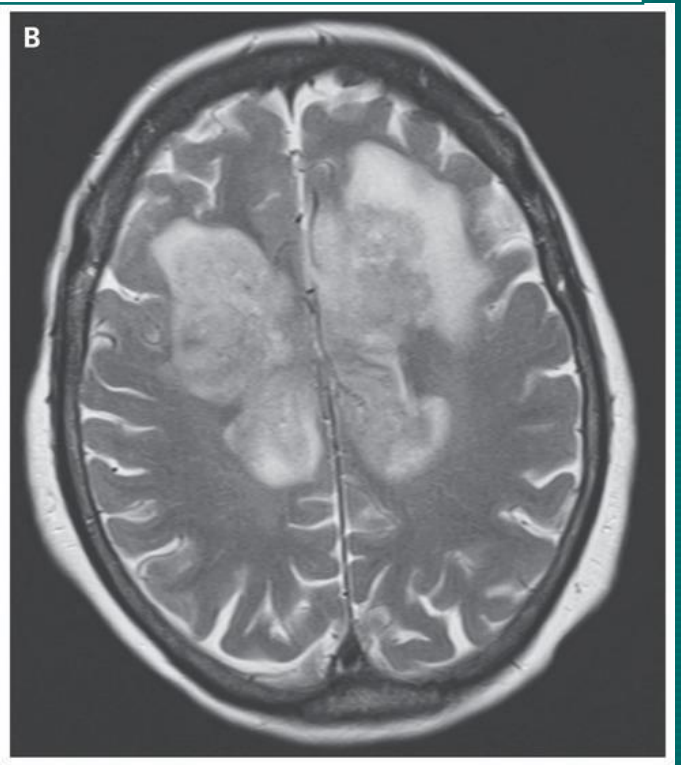
High-grade glioma>> Contrast-enhancement, with oedema, may have cystic or necrotic changes + pts are usually elderly



High-grade glioma affecting corpus callosum

Few lesions affect the corpus callosum..
When you see a lesion there, it could be lymphoma, GBM, MS
MS: hyper-intense lesions, multiple
GBM: heterogenous enhancement, diffuse enlargement, >> butterfly glioma





Cerebellar tumors

In adults:

- The most common cerebellar lesion is a metastasis. Even if solitary metastatic lesion
- The second most common tumor is a hemangioblastoma.

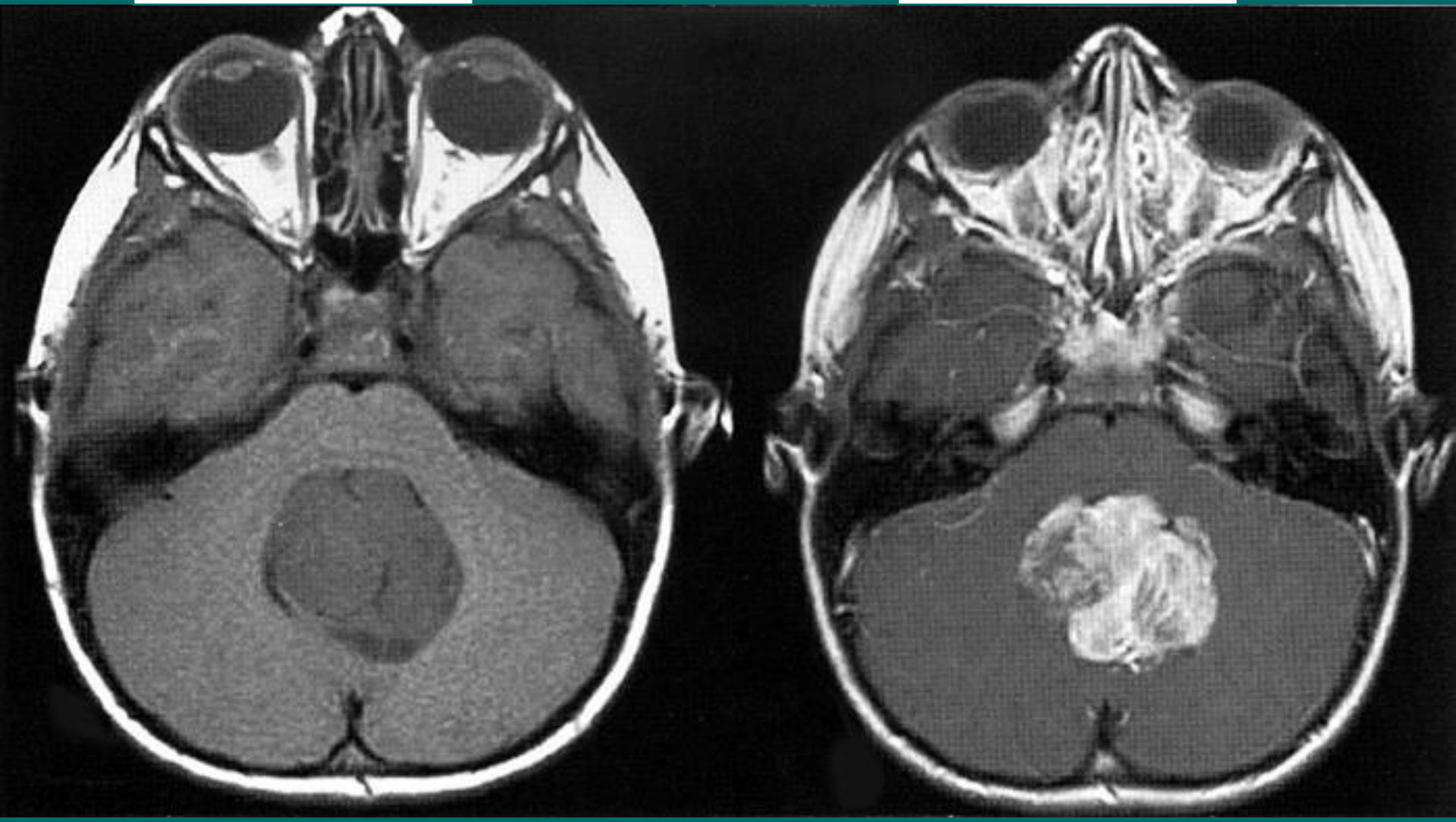
In children:

- Medulloblastoma: is the most common malignant brain tumor of childhood.
- Astrocytoma.
- Ependymoma.
- Brain stem glioma.
- Atypical teratoid rhabdoid tumour (ATRT)

Mass occupying the 4th ventricle

T1- pre-contrast

T1- post-contrast



If this pt is young >> medulloblastoma
If pt is adult >> metastasis

What are the common extra-axial tumors ?

- Meningiomas
- Neuromas
- Metastasis
- Pituitary tumors

Extra-axial tumours could arise from meninges, BVs, skull, pituitary, nerve sheath neuromas (most commonly schwannomas) or metastasis

Meningiomas

- Represent 15-20% of primary brain tumors.
- They are benign, well circumscribed lesions, arising from any part of the meningeal covering of the brain, most commonly in the parasagital region and sphenoid wing.
- Small punctate calcifications can be seen in 25% of tumors.
- CT or MRI show well defined lesions enhancing strongly and diffusely after intravenous contrast.

Extra-axial, well-defined, homogenously enhancing on MRI, sometimes with oedema
May see calcifications within the lesion (25%)
Typically affecting middle aged women
MRI is better than CT scan

Right frontal lobe convexity tumour (meningioma) with massive oedema causing compressing effect (we don't usually see as much oedema - this is atypical meningioma)

Pituitary tumors

- The plain films show pituitary fossa enlargement or erosion.
- Adenomas smaller than 1cm are microadenomas, and larger adenomas are macroadenomas.
- MRI is superior to CT in detecting adenomas.

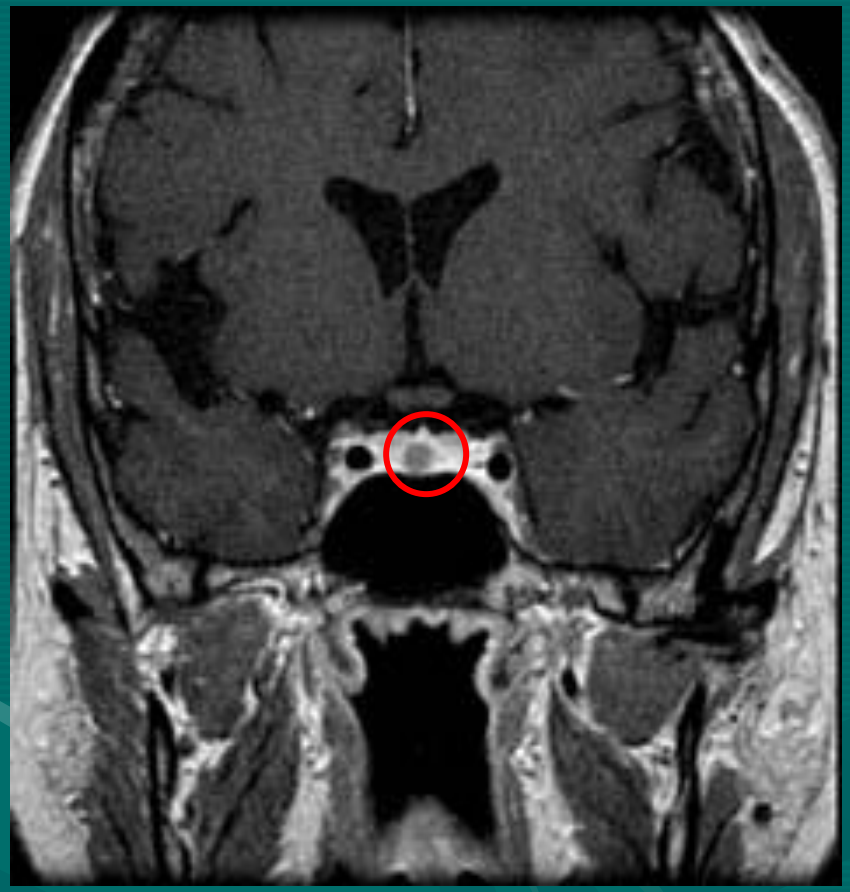
Micro- are usually functional, usually prolactinoma >> on imaging: well-defined area within the gland, less enhancing than the rest of the gland
Macro- involve the whole gland, extending beyond the suprasellar area, compressing the optic chiasm >> bitemporal hemianopia , usually non-functioning.. On imaging: large, homogenously enhancing pituitary, on coronal section you see 'figure of 8'

Acoustic neuroma:

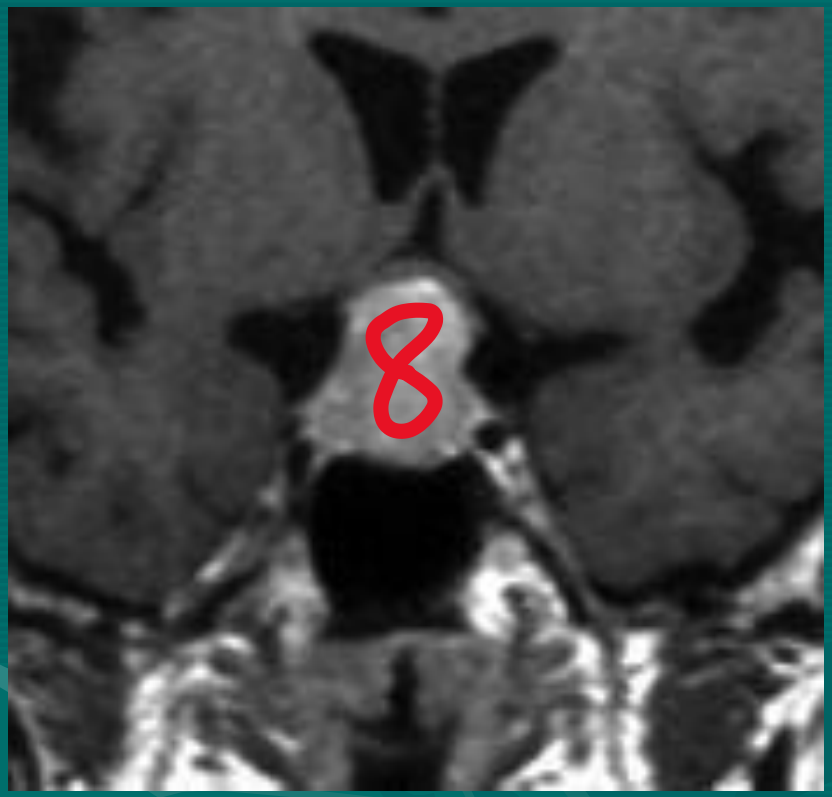
- Arise in or near the internal auditory canal and may cause widening and erosion of the canal.
- MRI is more sensitive than CT in its detection.

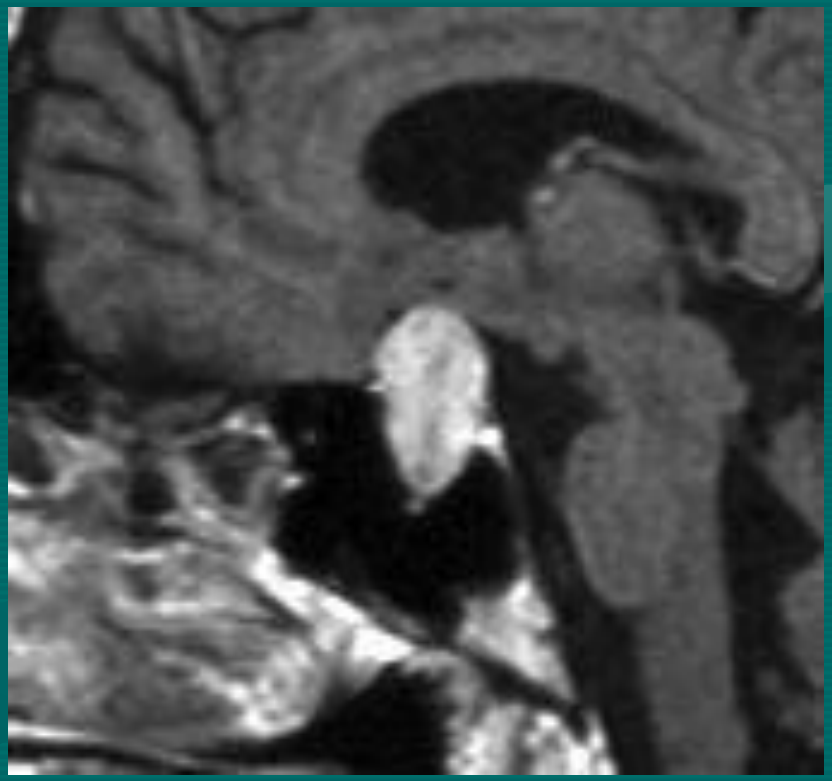
Neuromas arise from nerve sheath, they follow the tract of the nerve
Usually affects vestibulocochlear nerve >> called schwannoma, the nerve leaves the pons to inter the internal acoustic meatus through the cerebellopontine angle (CP angle) >> so, part of the tumour will be seen interring the internal acoustic meatus>> ice-cream cone shape
Well-defined, homogenously enhancing, may see cystic changes
To differentiate meningioma & schwannoma, meningioma doesn't extend to the internal acoustic meatus >> no ice-cream cone shape

MRI T1>> Small, well-defined area within the pituitary, less enhancing than the rest of the gland >> micro-adenoma of the pituitary gland



MRI T1 >> large, homogenously enhancing pituitary, ‘figure of 8’ on coronal section, involving the whole gland, extending beyond the suprasellar area, compressing the optic chiasm





MRI FLAIR with contrast >> Well-defined, homogenously enhancing, ice-cream cone shape on CP angle >> schwannoma

Well-defined, homogenously enhancing, no ice-cream cone shape on CP angle >> meningioma

Most commonly intra-axial but could be extra-axial

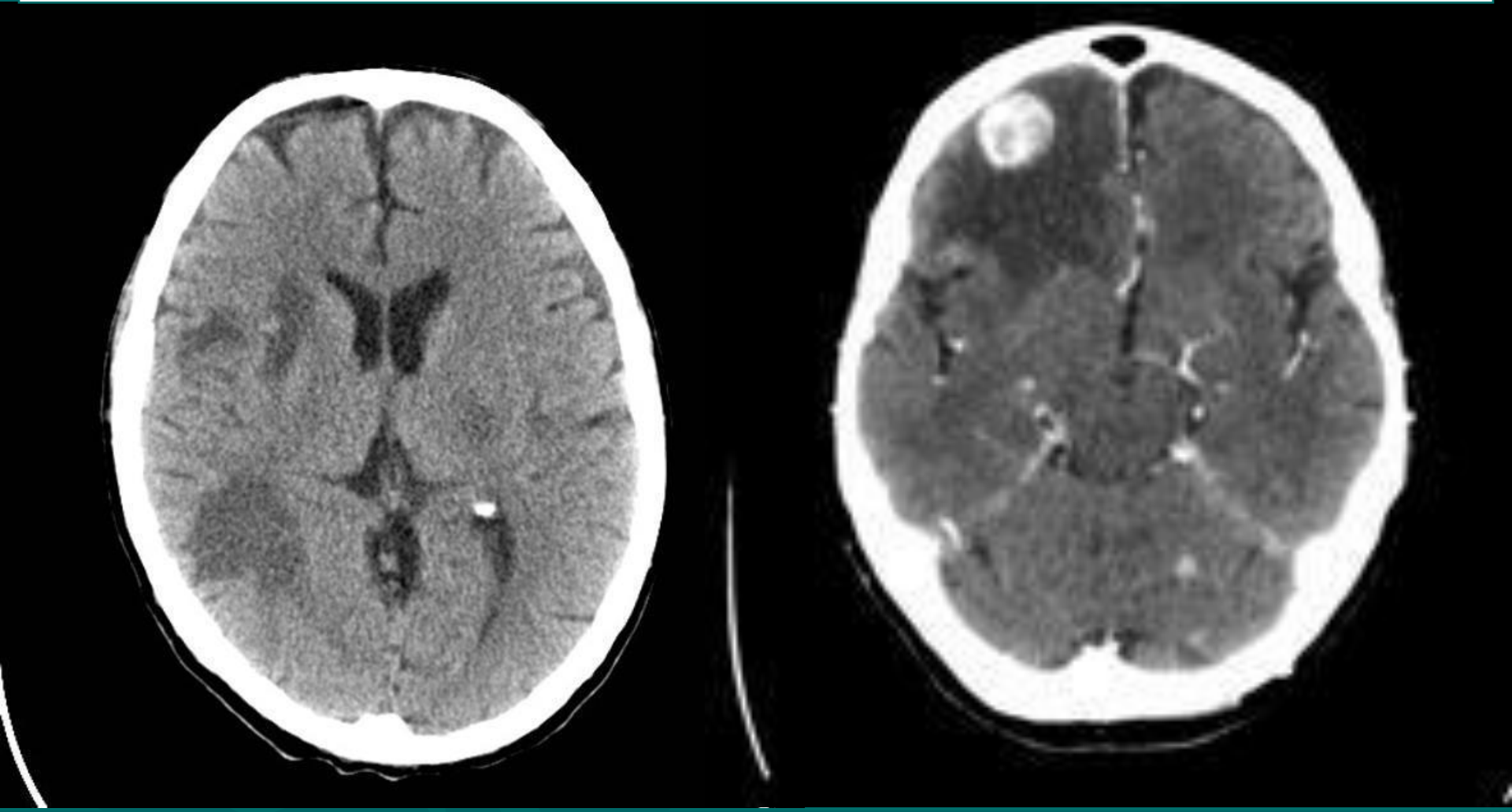
Brain metastasis

- The majority are multiple (80%)
- They can occur anywhere in the brain, but the gray-white matter junction is the commonest site.
- Metastatic lesions are usually associated with a considerable amount of surrounding edema.
- Brain metastasis are commonly from bronchial, breast and gastro-intestinal tumors.

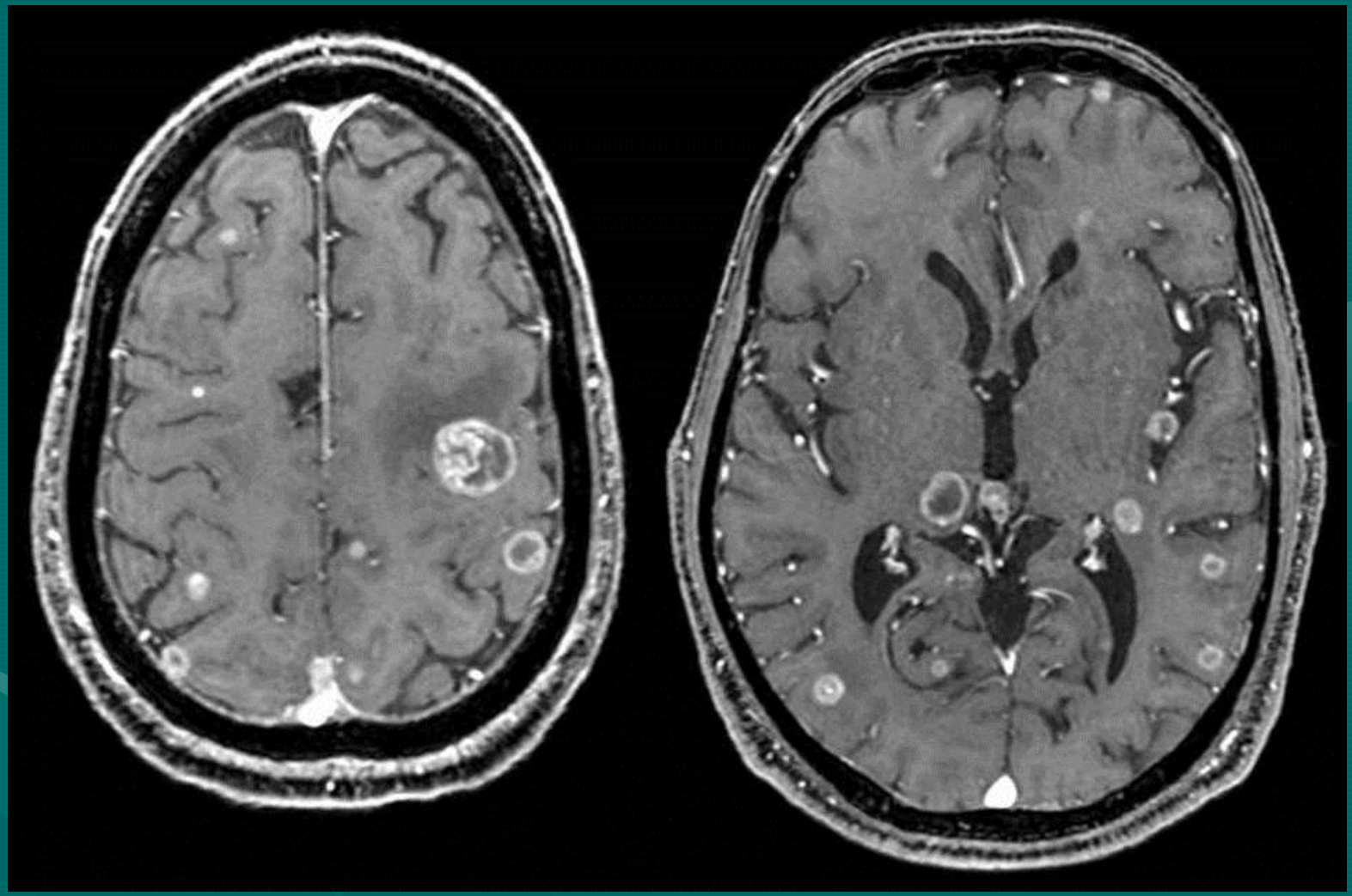
+ melanoma (melanoma produces haemorrhagic mets)

Radiologically>> multiple, well-defined, ring-enhancing lesions, usually at grey-white matter junction, oedema out-proportional to the size of the lesion

CT w/out contrast >> we may see the oedema but not the lesion itself
With contrast >> ring-enhancing….



MRI T1 >> Multiple lesions, ring-enhancing



**** Notes after the first lecture :

- When writing a report for brain tumor It's imp to know :
- If it is supra or infra "in posterior fossa"
- Age
- Cystic or solid
- Calcifications : in some tumors it is rare to find calcifications and in others it is common >>>> as in the(craniopharyngioma)In childs 90% Calcifications while in (medulloblastoma)it is impossible to find calcifications → Knowing these things about the mass helps us to determine the type of it .

**** In the barium follow through >>> the abdominal films which are taken in the first hour the pt should be in prone position because by the compression that the table makes on the pt's abdomen , the ileum would be visualized clearly .. after the first hour the films taken in supine position.


Thank
You